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Miyano

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(54) **MACHINING SYSTEM AND METHOD OF MACHINING A WORKPIECE USING THE MACHINING SYSTEM**

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(52) **U.S. Cl.** **82/1.11**; 82/129; 82/149; 82/901
(58) **Field of Search** 82/1.11, 142, 901, 82/124, 129, 149; 29/DIG. 50, 79, 94, 102

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(57) **ABSTRACT**

A machining system having a first machine tool assembly with a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder, and a second machine tool assembly having a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder. The machining system further includes a base assembly on which the first and second machine tool assemblies are supported in an operative position. At least a part of the first machine tool assembly is repositionable by movement along a first line. At least a part of the second machine tool assembly is repositionable by movement along a second line that is non-parallel to the first line. The parts of the first and second machine tool assemblies are relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies.

38 Claims, 5 Drawing Sheets

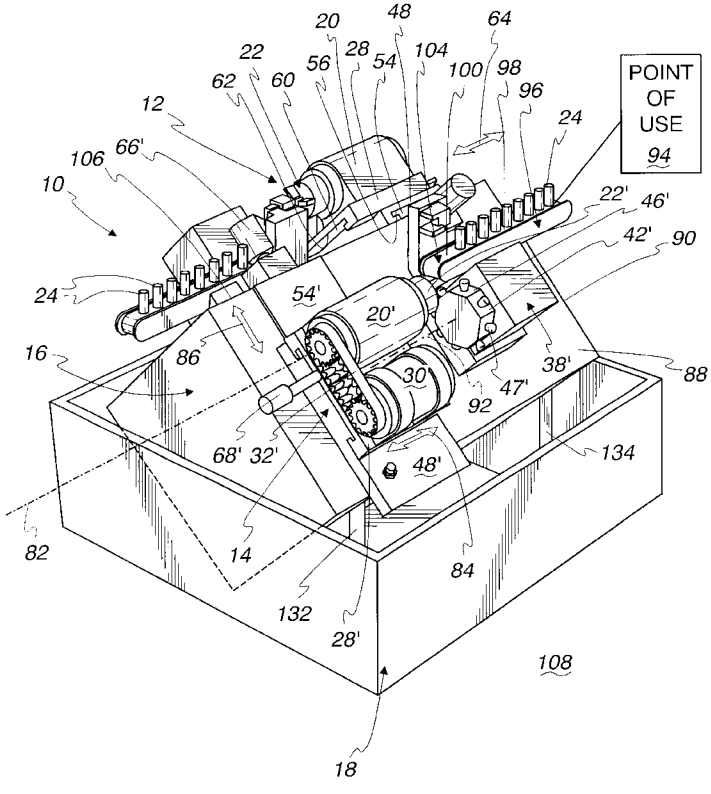
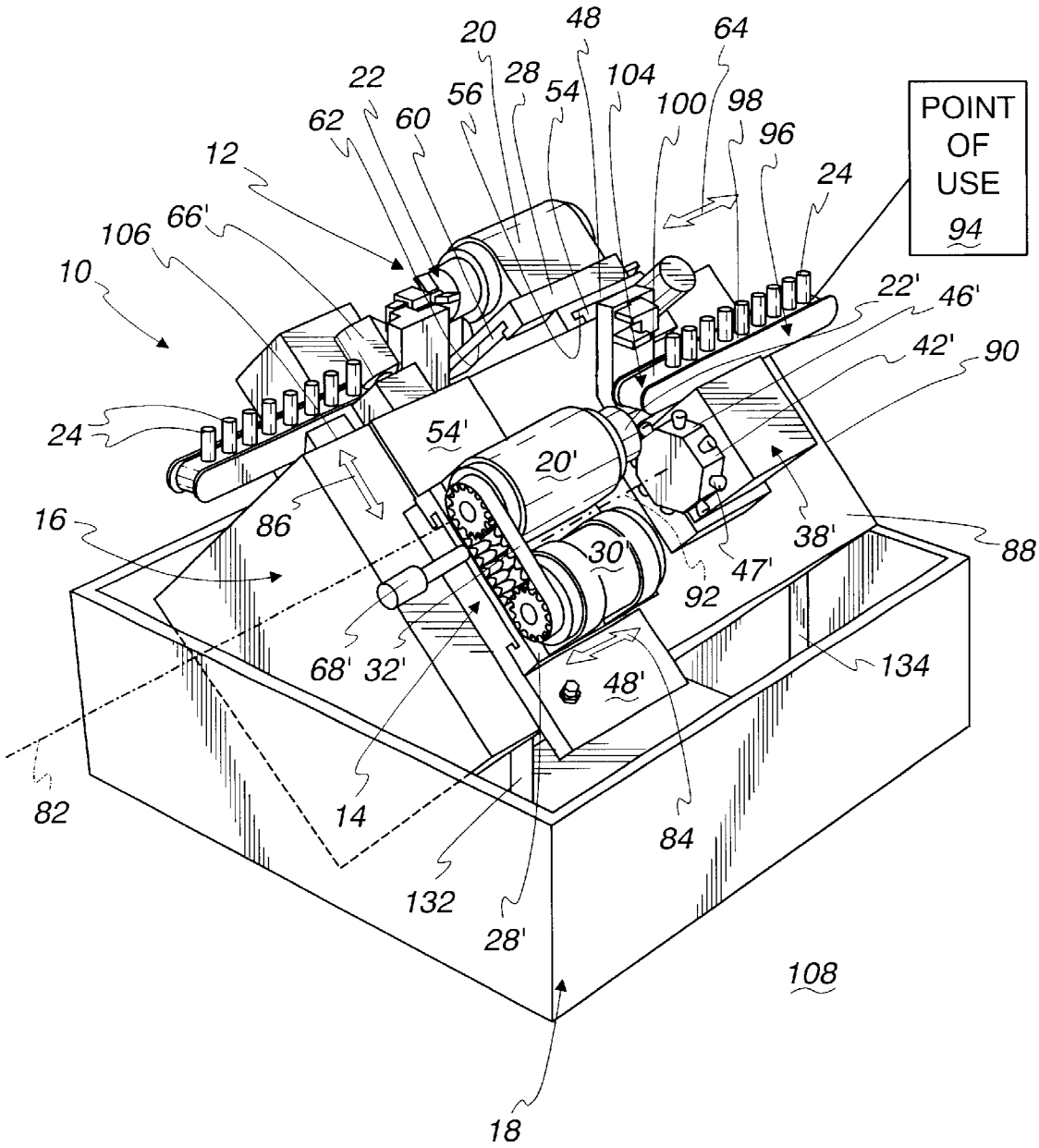


Fig. 1


POINT OF USE
94
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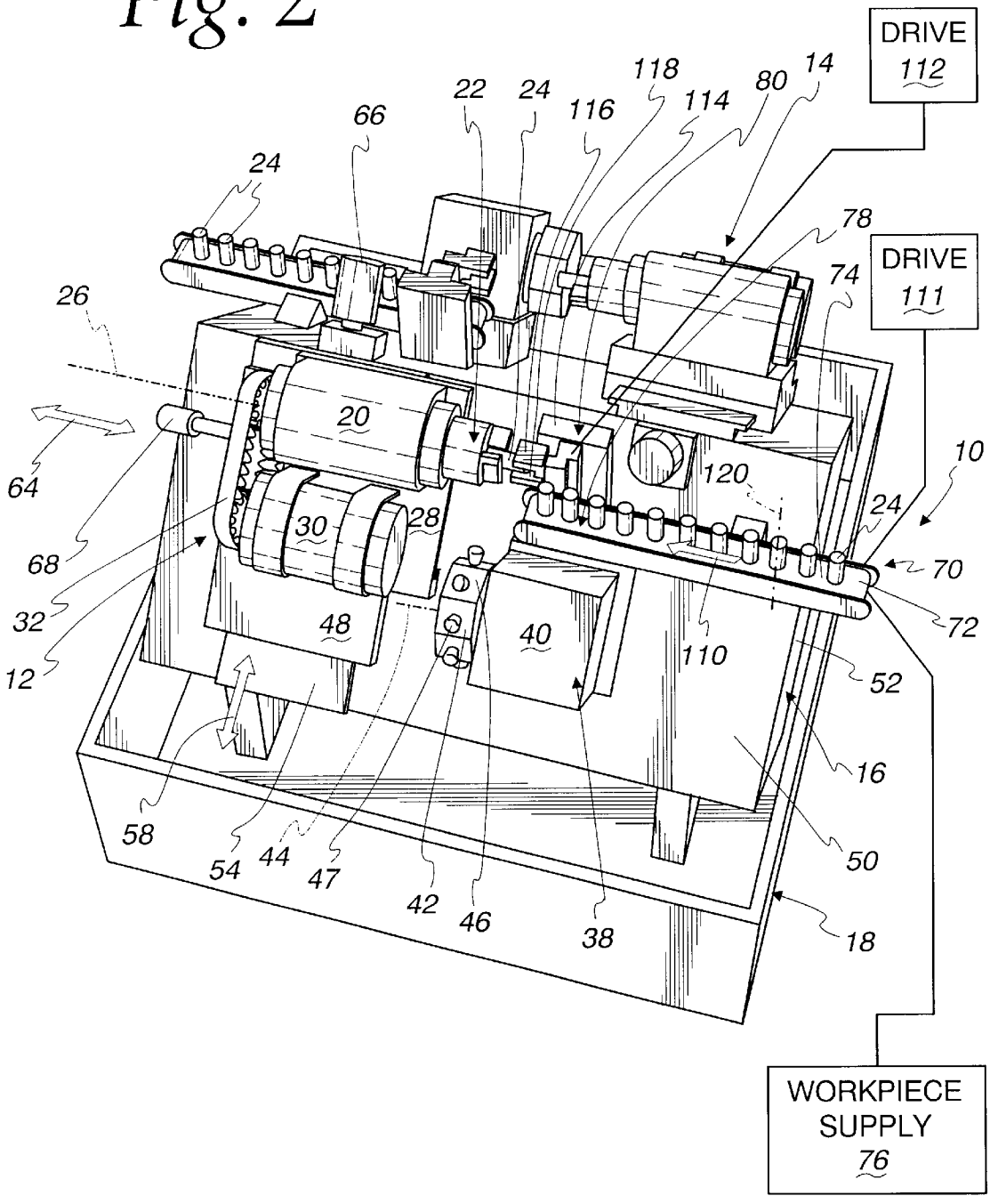
48
64
22
28
54
104
100
98
96
62
60
56
12
24
106
66'
10
22'
46'
42'
90
24
54'
20'
16
86
38'
88
30'
47'
92
68'
32'
48'
134
82
14
84
132
28'
108
18

Fig. 2


DRIVE
112
DRIVE
111
WORKPIECE
SUPPLY
76
66
22
24
116
118
114
80
14
78
74
26
64
20
10
120
24
68
30
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70
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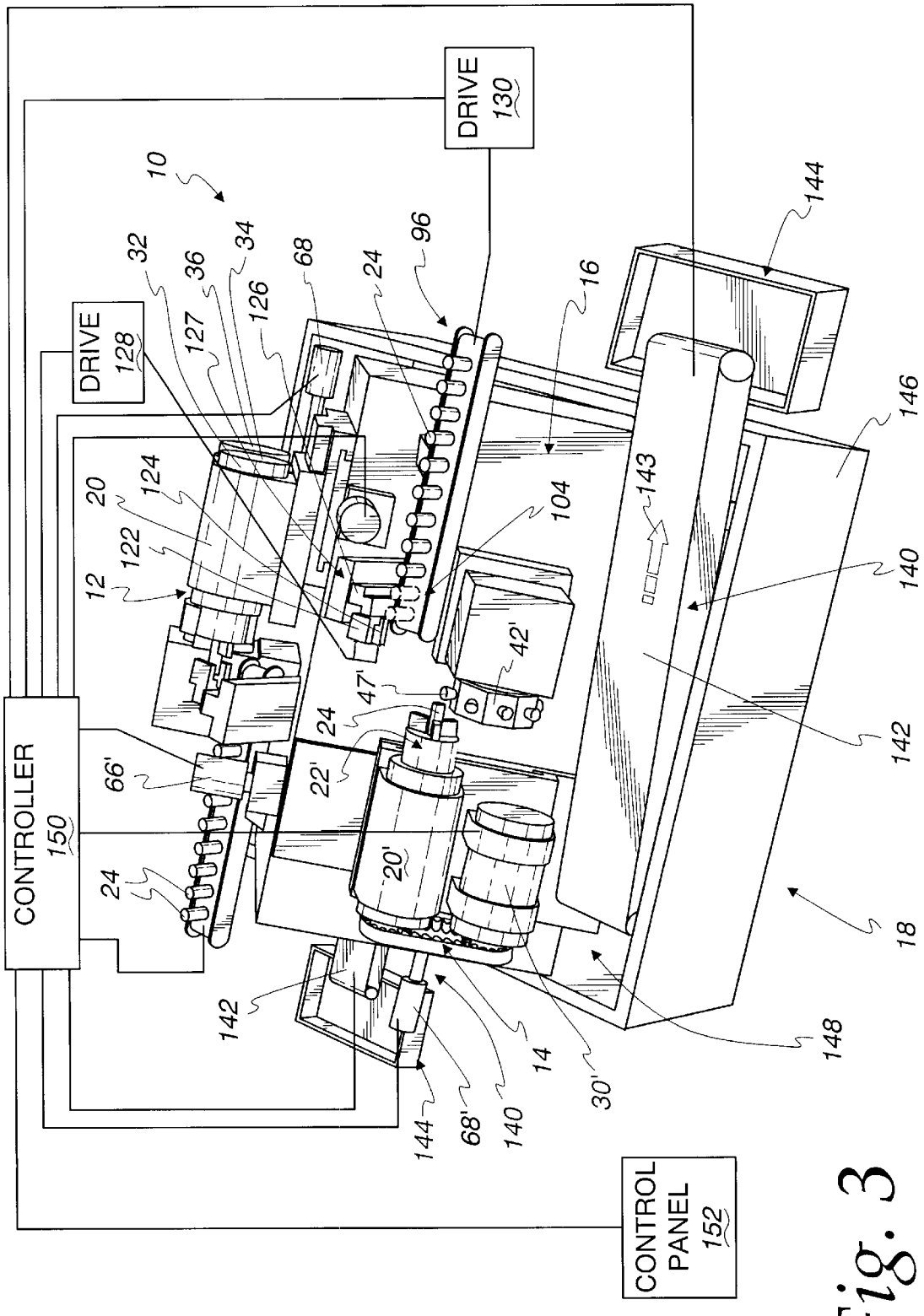
50
54
44
47
42
46
38
18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DRIVE 128
CONTROLLER 150
CONTROL PANEL 152
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12
14
16
18
20
20'
22'
24
30'
32
34
36
42'
47'
66'
68
68'
96
104
122
124
126
127
140
142
143
144
146
148

Fig. 3

Fig. 4

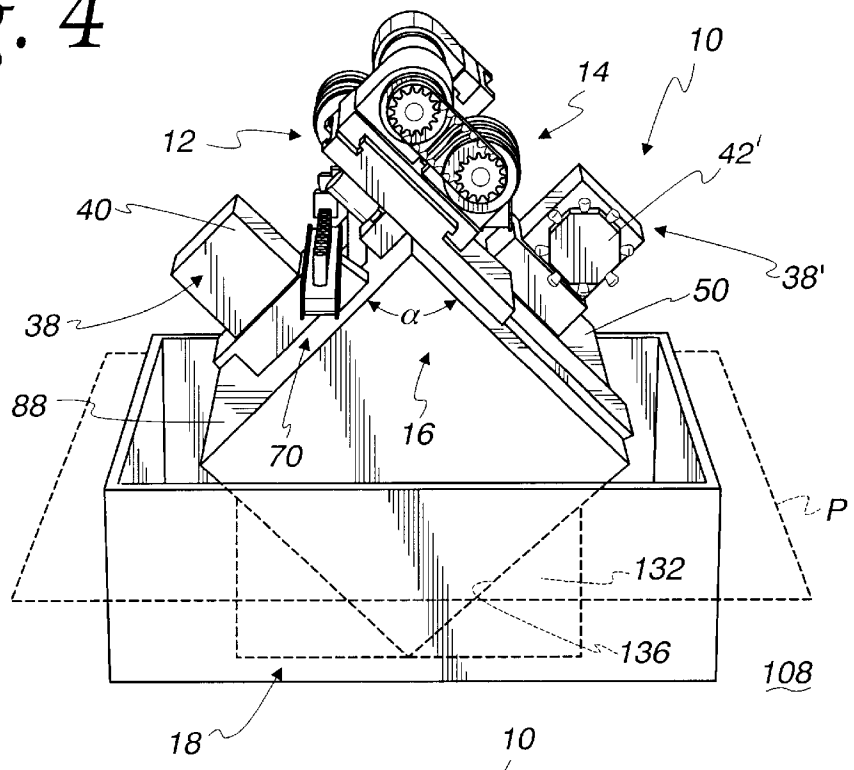
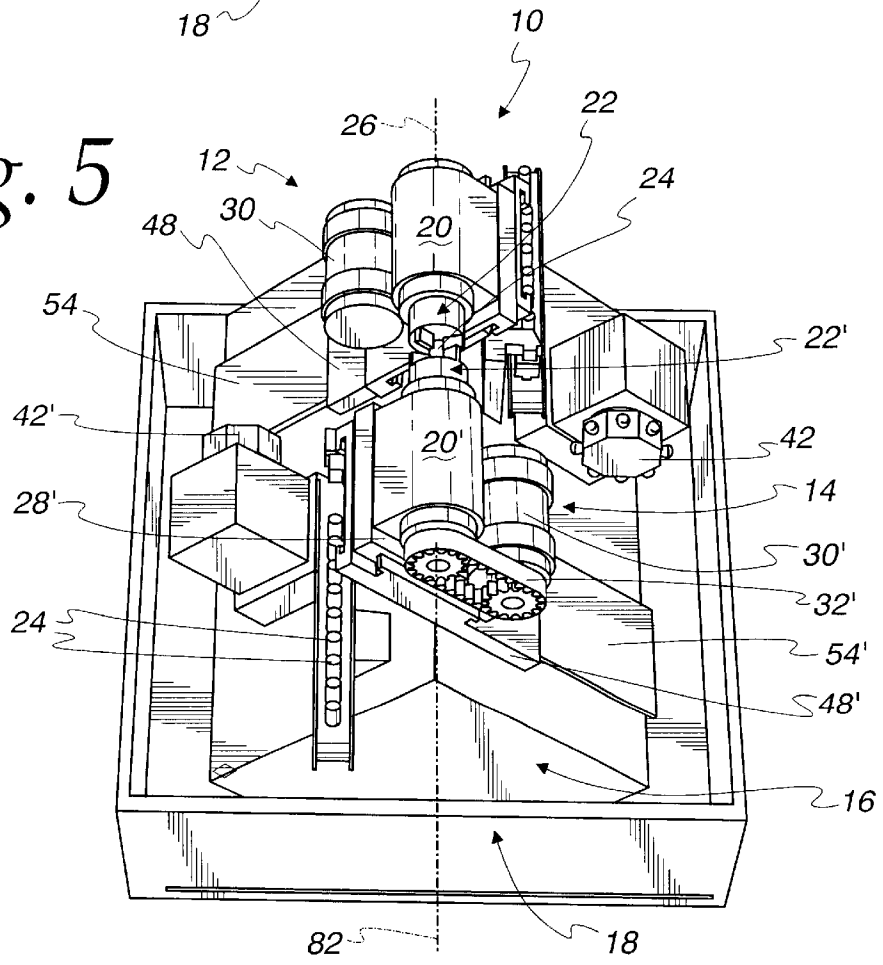

10
14
12
42'
40
38'
50
38
α
88
16
70
P
132
136
108
18

Fig. 5


10
26
22
12
24
30
48
20
54
22'
42'
20'
42
28'
14
30'
32'
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54'
48'
16
82
18

Fig. 6

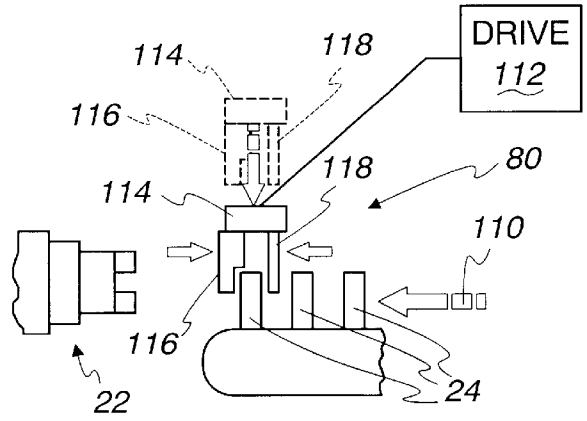


Fig. 7

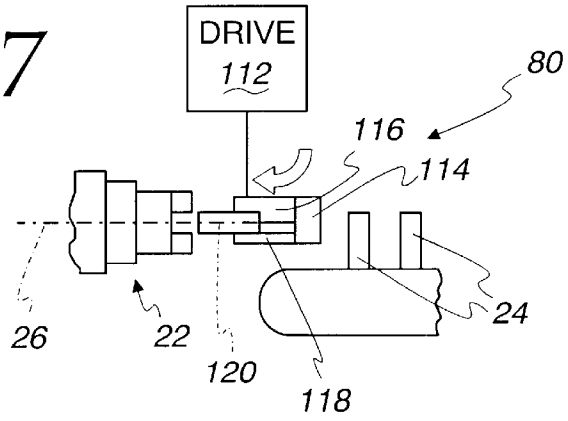


Fig. 8

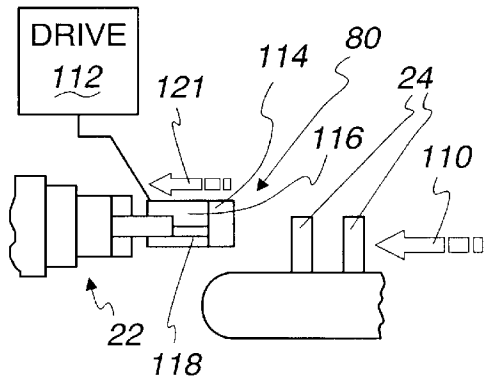
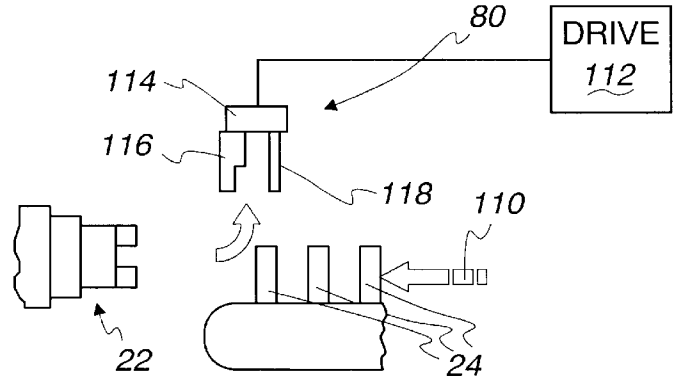


Fig. 9



MACHINING SYSTEM AND METHOD OF MACHINING A WORKPIECE USING THE MACHINING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a machining system through which workpieces are processed and, more particularly, to a machining system having a plurality of machine tool assemblies that cooperate in processing a workpiece.

2. Background Art

It is an objective of designers of machining systems to minimize space requirements without compromising either the versatility or performance of these systems. It is known to set up multiple machine tool assemblies in an operation and to move a workpiece from one machine tool assembly to another to serially perform processing operations thereon. The "footprint" for such systems may be quite large.

U.S. Pat. No. 4,612,832 discloses a machining system in which a machine tool assembly is disposed angularly to its normal orientation. During machining, the workpiece is moved in a plane that is non-horizontal. An inclined surface underlies the machine tool assembly and guides lubricant, and pieces of a workpiece removed during processing, downwardly to a collection base. This arrangement reduces the footprint over what it would be with the machining system in a horizontal orientation.

It is also known to situate machine tool assemblies so that the operating axes thereof extend in a vertical direction. One example of such a system is shown in U.S. Pat. No. 1,782,138. This arrangement likewise results in a reduced footprint.

SUMMARY OF THE INVENTION

In one form, the invention is directed to a machining system having a first machine tool assembly with a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder, and a second machine tool assembly having a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder. The machining system further includes a base assembly on which the first and second machine tool assemblies are supported in an operative position. At least a part of the first machine tool assembly is repositionable by movement along a first line. At least a part of the second machine tool assembly is repositionable by movement along a second line that is non-parallel to the first line. The parts of the first and second machine tool assemblies are relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies.

In one form, the first machine tool assembly has a first central operating axis and the second machine tool assembly has a second central operating axis. The first line and a third line parallel to the first central operating axis reside in a first plane. The second line and a fourth line parallel to the second central operating axis reside in a second plane. The first and second planes are non-parallel to each other.

The first and second planes may define a downwardly opening angle of less than 135° therebetween. This angle may be on the order of 90°.

In one form, the first line extends at an angle to a horizontal reference plane.

In one form, the part of the first machine tool assembly includes a first headstock and the part of the second machine tool assembly includes a second headstock. Each of the headstocks has a central axis. The first and second headstocks are relatively repositionable into a workpiece exchange position wherein the central axes of the first and second headstocks are substantially coincident.

The base assembly may include first and second substantially flat surfaces cooperatively defining an inverted V shape. In one form, the first machine tool assembly is mounted on the first flat surface and the second machine tool assembly is mounted on the second flat surface.

The machining system may further include an upwardly opening receptacle for collecting foreign matter deposited on the first and second flat surfaces.

In one form, the base assembly further has an upwardly projecting support. The first flat surface has a width extending parallel to the central axis of the first headstock, with the upwardly projecting support having a width dimension parallel to the central axis of the first headstock that is substantially less than the width of the first flat surface.

In one form, the first workpiece holder is a first headstock and the first machining unit is an indexable turret with a plurality of machining tools.

The first machine tool assembly may further include a first conveyor for delivering workpieces to be processed to a transfer position.

The machine tool assembly may further include a first transfer mechanism to engage a workpiece on the first conveyor and deliver an engaged workpiece toward a position at which the engaged workpiece can be operatively held by the first headstock.

The machine tool assembly may further include a second conveyor for delivering workpieces from the second workpiece holder to a point of use.

The second machine tool may include a second transfer mechanism to engage a workpiece on the second workpiece holder and deliver an engaged workpiece to a second conveyor.

The first transfer mechanism may have first and second jaws that are relatively movable between a gripping position, to hold a workpiece, and a release position.

In one form, the first central operating axis extends in a horizontal direction.

The invention is also directed to a machining system having a first machine tool assembly with a first headstock for holding a workpiece on which a processing operation is to be performed and a second machine tool assembly having a second headstock for holding a workpiece on which a processing operation is to be performed. The machining system further includes a base assembly on which the first and second machine tool assemblies are supported in an operative position. The first headstock is movable along two transverse axes residing in a first plane. The second headstock is movable along two transverse axes residing in a second plane. The first and second planes are non-parallel to each other.

In one form, the first and second planes cooperatively define an inverted V shape.

The first and second planes may open downwardly at an angle of less than 135°. The angle may be on the order of 90°.

The invention is also directed to a machining system including a first machine tool assembly having a first headstock for holding a workpiece on which a processing opera-

tion is to be performed and a second machine tool assembly having a second headstock for holding a workpiece on which a processing operation is to be performed. The machine tool assembly further includes a base assembly on which the first and second machine tool assemblies are supported in an operative position. The base assembly has a first substantially flat surface and a second substantially flat surface which is angularly oriented relative to the first flat surface so that first and second planes including the first and second flat surfaces define an inverted V shape. The first machine tool assembly resides above the first flat surface so that at least one of a lubricant and pieces of a workpiece removed during processing using the first machine tool assembly are guided downwardly by the first surface. The second machine tool assembly resides above the second flat surface so that at least one of a lubricant and pieces of a workpiece removed during processing using the second machine tool assembly are guided downwardly by the second surface.

The machining system may further include an upwardly opening receptacle for collecting at least one of lubricant and pieces of a workpiece removed during processing using the first machine tool assembly and guided downwardly by the first surface.

The first machine tool assembly may include a first headstock for holding a workpiece. The machine tool assembly may include a second headstock for holding a workpiece, with the first and second headstocks being relatively repositionable so as to facilitate exchange of a workpiece between the first and second headstocks.

In one form, the first and second headstocks have first and second axes and are relatively repositionable into an exchange position wherein the central axes of the first and second headstocks are substantially coincident.

In one form, the first headstock is positionable in an operating position and movable in a first plane between the operating position and a position in which the first headstock resides with the first and second headstocks in the exchange position. The first plane is angularly oriented relative to a horizontal reference plane.

In one form, the second headstock is positionable in an operating position and is movable in a second plane between the operating position for the second headstock and a position in which the second headstock resides with the first and second headstocks in the exchange position. The second plane is angularly oriented relative to the first plane and a horizontal reference plane.

The first and second planes may cooperatively define an inverted V shape.

The invention is also directed to a method of machining a workpiece, including the steps of: performing a first processing operation on a first workpiece using a first machine tool assembly; at the completion of the first processing operation moving the first workpiece in a first line that extends in a vertical direction; transferring the first workpiece to a second machine tool assembly; performing a second processing operation on the first workpiece; and moving the first workpiece along a second line that is non-parallel to the first line and extends in a vertical direction.

The first and second lines may cooperatively define an inverted V shape.

The method may further include the step of directing at least one of lubricant and pieces of the first workpiece removed during the first processing operation along a first inclined surface downwardly to a collection area.

The method may further include the step of collecting the at least one of lubricant and pieces of the first workpiece removed during the first processing operation in a receptacle.

The method may further include the step of directing at least one of lubricant and pieces of the first workpiece removed during the second processing operation along a second inclined surface downwardly to a collection area.

The first and second inclined surfaces may cooperatively define an inverted V shape.

In one form, the step of transferring the first workpiece involves repositioning at least one of a first headstock on the first machine tool assembly and a second headstock on the second machine tool assembly so that the first and second headstocks are in an exchange position so that the first workpiece can be transferred directly from the first headstock to the second headstock.

In one form, the first and second headstocks each have a central axis, and with the first and second headstocks in the exchange position, the central axes of the first and second headstocks are substantially coincident.

The step of performing the first processing operation may involve performing a first processing operation using a tool on a first indexable turret.

The step of performing a second processing operation may involve performing a second processing operation using a tool on a second indexable turret.

The method may further include the steps of advancing the first workpiece on a first conveyor toward a first headstock on the first machine tool assembly and through a first transfer mechanism engaging the first workpiece and delivering the first engaged workpiece to the first headstock.

The method may further include the steps of using a second transfer mechanism to remove the first workpiece from a second headstock on the second machine tool assembly and transferring the engaged first workpiece to a second conveyor through which the first workpiece is advanced to a point of use.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a machining system, according to the present invention, including first and second machine tool assemblies, and taken from one end and side thereof;

FIG. **2** is a perspective view of the machining system taken from the side opposite that in FIG. **1**;

FIG. **3** is a perspective view of the machining system taken from the same side as in FIG. **1** and from the opposite end;

FIG. **4** is a perspective view of the machining system taken from the same end as in FIG. **1** and with the machine tool assemblies relatively situated to exchange a work piece therebetween;

FIG. **5** is a perspective view from overhead and from the same end as in FIG. **4** with the machining tool assemblies relatively situated as in FIG. **4**; and

FIGS. **6**, **7**, **8**, and **9** are fragmentary, side elevation views showing the sequence of transferring individual workpieces from a supply to spindles on one of the machine tool assemblies and withdrawing the same for transfer to a point of use.

DETAILED DESCRIPTION OF THE DRAWINGS

A machining system, according to the present invention, is shown in the Figures generally at **10**. The machining

system **10** consists of a first machine tool assembly at **12** and a second machine tool assembly at **14**, which are supported in an operative position on a base assembly at **16**. The base assembly **16** is mounted within an upwardly opening receptacle **18** into which foreign matter, such as lubricant and pieces of workpieces, removed during processing operations, can be accumulated.

The machine tool assemblies **12,14** are shown to have a similar construction. However, the inventive concept can be utilized with virtually any configuration of machine tool assembly. The machine tool assemblies shown are but exemplary in nature. The exemplary first machine tool assembly **12** consists of a first workpiece holder/headstock **20** which has a first spindle **22** for releasably gripping a workpiece **24** and which is rotatable around a central operating axis **26**. The first headstock **20** is mounted on a first slide element **28**. A first drive motor **30** is mounted on the slide element **28** and is operated to drive the spindle **22** about the axis **26**. A drive force is transmitted from the motor **30** to the spindle **22** through an endless drive belt **32** trained around pulleys **34, 36** on each of the headstock **20** and motor drive shaft.

The first machine tool assembly **12** further includes a first machining unit **38** which consists of a base **40** to which an indexable turret **42** is mounted. The turret **42** is pivotable about a horizontal axis **44** that is substantially parallel to the spindle axis **26**. The turret **42** has a polygonally-shaped outer surface **46**, with each flat face thereon supporting a machining tool **47** for performing a processing operation on a workpiece.

The first slide element **28** cooperates with a second slide element **48** which is in turn mounted to an inclined surface **50** on a wall **52** of the base assembly **16**. The wall **52** has a guide rail **54** projecting upwardly from the surface **50** and extending at an angle to horizontal. The guide rail **54** has a T-shaped cross section which fits in a complementary slot **56** formed in the second slide element **48**. Through this arrangement, the second slide element **48** is guided relative to the base surface **50** along a line indicated by the double-headed arrow **58**.

The second slide element **48** has a horizontally extending guide rail **60** with a T-shaped cross-sectional configuration that fits within a complementary slot **62** on the first slide element **28**. Through this rail and slot arrangement, the first slide element **28** is movable guidingly relative to the second slide element **48** in a substantially horizontal line, indicated by double-headed arrow **64**. The line of the arrow **64** is substantially orthogonal to the line of the arrow **58**.

Servomotors **66,68** are mounted to the base assembly **16** and second slide element **48** to respectively move the slide element **48** along the line **58** and the slide element **28** along the line **64**. The requisite movement imparted by the servomotors **66,68** may be effected through any mechanism well known to those skilled in the art. For example, the servomotors **66,68** may be operable to rotate a worm drive. Alternatively, hydraulic-type cylinders could be utilized to effect the necessary movement of the slide elements **28,48**.

A feeding conveyor **70** has an endless belt **72** with an upwardly facing support surface **74** on which individual workpieces **24** can be supported and advanced from a supply **76** to a transfer location at **78**.

The first machine tool assembly further includes a first transfer mechanism at **80**. As will be explained in greater detail below, the first transfer mechanism **80** engages a workpiece **24** at the transfer location **78** on the feeding conveyor **70** and delivers the same to a position wherein the workpiece **24** can be engaged by the spindle **22** on the headstock **20**. Once the active workpiece **24** is operatively held by the spindle **22**, the slide element **28** can be moved to the left in FIG. **2** along the line **64**. Thereafter, downward movement of the second slide element **48** situates the active workpiece **24** in operative relationship with a machining tool **47** on the turret **42**.

The second machine tool assembly **14** is shown to have essentially the same elements as the first machine tool assembly **12**. However, this is not necessary, and, as noted above, the second machine tool assembly **14** could have a configuration totally different from that of the first machine tool assembly **12**. Throughout this description, elements on the second machine tool assembly **14** corresponding to those on the first machine tool assembly will be identified with like numbers, including a "'".

The second machine tool assembly **14** consists of a second workpiece holder/headstock **20'** which has a spindle **22'** that is rotated around a central operating axis **82**. The spindle **22'** is driven by a drive motor **30'** through an endless drive belt **32'**. The headstock **20'** and motor **30'** are mounted upon a slide element **28'** which is guided relative to a slide element **48'** in a horizontal line as indicated by double-headed arrow **84**. The slide element **48'** is guided in a direction along a line at an angle to horizontal as indicated by the double-headed arrow **86** along a guide rail **54'**, which projects upwardly from a flat surface **88** on a wall **90** of the base assembly **16**.

The wall **90** supports a second machining unit **38'** which includes an indexable turret **42'** which is movable around an axis **92**. The turret **42'** has a polygonally-shaped outer surface **46'** upon which the plurality of machining tools **47'** are mounted. Servomotors **66',68'** are operable to reposition the slide **48'** and slide **28'**, respectively, along the lines **86,84**.

As explained below, after the processing operation is performed by the first machine tool assembly **12** on a workpiece **24**, the workpiece **24** is transferred to the second machine tool assembly **14** through which a separate processing operation may be performed thereon. At the conclusion of the second processing operation, the workpiece **24** is transferred from the second headstock **20'** to a point of use **94**. This transfer is effected using a discharge conveyor **96** that is similar in construction to the feeding conveyor **70**. That is, the discharge conveyor **96** has an endless belt **98** with a supporting surface **100** for workpieces **24**. Through the transfer mechanism **80**, the individual workpieces **24** on the spindle **22'** are engaged, removed therefrom, and placed at a transfer location **104** on the supporting surface **100** of the discharge conveyor **96**. The endless belt **98** is then operated to direct the workpieces **24** serially from the transfer location **104** to the point of use **94**.

The inclined wall surfaces **50,88** are preferably flat and meet at an apex **106**. The surfaces **50,88** cooperatively define an inverted V-shape with an included angle α. The angle α is preferably less than 135° and more preferably on the order of 90°. The surfaces **50,88** are dimensioned so that foreign material, since as lubricant and particles removed from workpieces during processing, and deposited thereon, moves under the force of gravity downwardly and into the receptacle **18** for accumulation therewithin. The surfaces **50, 88** have portions that are flat and uninterrupted from a location adjacent to the first and second workpiece holders/headstocks **20, 20'** to a bottom edge of the base assembly **16** residing immediately over the receptacle. The lines of vertical movement of the headstocks **20,20'**, as indicated by the arrows **58,86**, are preferably substantially parallel to the

planes of the flat surfaces **50,88**. Similarly, the lines of movement of the headstocks **20,20'** in a horizontal direction, as indicated by the arrows **64,84**, are parallel to the planes of the flat surfaces **50,88**. The horizontal lines of movement indicated by the arrows **64,84** are preferably substantially parallel to the operating axes **26,82** for the headstocks **20,20'** and the axes **44,92** for the indexable turrets **42, 42'**. While the flat surfaces **50,88** may be at different angles with respect to a horizontal reference plane P (FIG. **4**), in a preferred form, each of the surfaces **50,88** has the same angle of inclination relative to the horizontal reference plane P that is parallel to a flat, subjacent support surface **108** upon which the machining system **10** is placed.

One exemplary machining operation will now be described. As seen in FIG. **2**, individual workpieces **24** are delivered from the supply **76** onto the support surface **74** which is advanced to move the workpieces **24** in the direction of the arrow **110** toward the transfer location **78**. Once this occurs, a drive **111** for the feeding conveyor **70** interrupts operation thereof. The details of operation of the transfer mechanism **80** are shown additionally in FIGS. **6–9**. A drive **112** is operated to reposition a transfer arm **114** to a position shown in phantom lines in FIG. **6**, wherein the transfer arm **114** is in a pickup position and retracted so that a pair of jaws **116,118** on the transfer arm **114** can be placed in a straddling position relative to a workpiece **24** at the transfer location **78**. The drive **112** is then operated to translate the transfer arm **114** down to the solid line position in FIG. **6**. As this occurs, the jaws **116,118** are maintained in a release position, in which they are spaced a distance greater than the dimension of the straddled workpiece **24**. In the solid line position in FIG. **6**, the jaws **116,118** can be moved towards each other to a gripping position, in which they clampingly engage a workpiece **24** at the transfer location **78**. The transfer arm **114** is then pivoted to the position shown in FIG. **7**, wherein the operating axis **120** of the workpiece **24** held by the transfer arm **114** is coincident with the central operating axis **26** of the headstock **20**. The headstock **20** is actually slightly backed off to the left in FIG. **2** as the transfer arm **114** pivots to the solid line position FIG. **7**. This allows the transfer arm **114** and workpiece **24**, engaged thereby, to clear the spindle **22**. Once the coaxial relationship between the workpiece **24** and the headstock axis **26** is established, the headstock **20** can be translated to the right in FIG. **2**, and/or the transfer arm **114** can be translated to the left, as indicated by the arrow **121**, in FIG. **8**, until the workpiece **24** moves into the spindle **22** sufficiently to be engaged thereby. Once this engagement occurs, the jaws **116,118** on the transfer arm **114** can be moved to the release position. Through operation of the motor **68**, the slide element **28** is moved to the left together with the workpiece **24** engaged in the spindle **22**. The transfer arm **114** is then moved to the FIG. **9** position, from where another workpiece pickup and transfer operation can be initiated. Thereafter, the servomotor **66** is operated to drive the slide element **48** downwardly to situate the active workpiece **24** in the spindle **22** at the turret **42** so that it can be processed by the active machining tool **47** on the turret **42**. One or more processing operations may be performed through one machining tool **47**, or a combination of different machining tools **47**, on the turret **42**.

At the completion of processing by the first machine tool assembly **12**, the first and second headstocks **20,20'** are relatively repositioned to an exchange position, shown in FIG. **5**, wherein the central operating axes **26,82** for the headstocks **20,20'** are coincident. The exchange position is realized by vertically moving the slide elements **48,48'** upwardly along their respective guide rails **54,54'**. Once the exchange position is realized, one or both of the servomotors **68,68'** can be operated to move the headstocks **20,20'** closer together. As this occurs, the workpiece **24** held by the spindle **22** on the first headstock **20** can be transferred to the spindle **22'** on the second headstock **20'**. By locking the spindle **22'** on the workpiece **24** and releasing the spindle **22**, the workpiece **24** transferred from the spindle **22** becomes operatively held on the headstock **20'**. By operating one or both of the servomotors **68,68'**, the spacing between the headstocks **20,20'** can be increased sufficiently that the headstock **20'** can be moved downwardly along the guide rail **54'** so that the workpiece **24** held thereby can be situated as shown in FIG. **3** so that a further processing operation can be performed by one or more by machining tools **47'** on the turret **42'**. At the completion of this processing operation, the workpiece **24** can either be returned to the headstock **20** for further processing or transferred to the discharge conveyor **96** for conveyance to the point of use **94**.

In the latter case, the headstock **20'** can be repositioned through operation of the servomotors **66',68'** to direct the active workpiece **24** between jaws **122,124** on a transfer arm **126** on a second transfer mechanism **127**. The transfer mechanism **127** may be identical to the transfer mechanism **80**. Once the workpiece **24** is moved between the jaws **122,124**, the jaws **122,124**, through a drive **128**, can be moved toward each other to gripping position to achieve a position corresponding to that in FIG. **8**. By releasing the spindle **22'** and retracting the headstock **20'** away from the transfer mechanism **80** to achieve a position corresponding to that in FIG. **7**, the transfer arm **126** is allowed to pivot to a position corresponding to that in FIG. **5**. This situates the workpiece **24** held thereby at the transfer location **104**. By then placing the transfer arm **126** in a position corresponding to that in FIG. **9**, the discharge conveyor **96** can be operated by a drive **130** to advance the processed workpieces **24** to the point of use **94**, which may be a collection bin, or otherwise.

Accordingly, with the above system, it is possible to coordinate operation of the first and second machine tool assemblies **12,14** so that they function as a unit. Efficient space utilization is possible without compromising any of the performance characteristics of either machine tool assembly **12,14**.

The base assembly **16** may be maintained in the operative state shown by one or more upwardly projecting supports **132,134**. The supports **132,134** may define cradle surface **136** (shown only for support **132**) having a shape complementary to that of the base assembly **16**. With this arrangement, the supports **132,134** effectively isolate the walls **52,90** from the coolant to efficiently dissipate potentially detrimental heat generated through the base assembly during machining operations. The supports **132,134** themselves may be made with a width in a horizontal direction that is substantially less than the width dimension of the surfaces **50,88** taken parallel to the operating axes **26,82**.

A conveyor system at **140**, consisting of a driven endless belt **142**, may be used to intercept and continuously convey parts of workpieces, removed during processing, in the direction of the arrow **143** to a collection receptacle **144** for accumulation and ultimately disposal. The system **140** can be provided on one side, or on opposite sides of the machining system **10**. The belt **142** may be made from wire material so that lubricant can migrate therethrough into the receptacle **18**. The conveyor system **140** may have multiple, cooperating sections (not shown) which direct the picked up parts of the workpieces horizontally through the receptacle **18** and thereafter upwardly and over a peripheral retaining

wall **146** which bounds an accumulation space **148** within the receptacle **18**. For simplicity, the belt **142** is shown as a single length, angled upwardly at the downstream end.

The above-described construction lends itself to the use of relatively large motors **30**, **30'**. A large motor construction facilitates smooth, high speed spindle operation.

While the invention contemplates that the bases **40**, **40'** for the turrets **42**, **42'** could be movable, the stationary base construction accounts for a fixed cutting point. Coolant can be directed consistently at the active machining tool **47**. Accordingly, predictable cooling permits aggressive and high speed processing to be undertaken without fear of premature wear on the machining tools **47**. A stable support for the cutting tools **47**, resulting from the fixed base arrangement, also may contribute to predictable alignment of cooperating elements on the machine tool assemblies **12**, **14**, and thereby high machining accuracy.

By reason of potentially compacting the overall size of the system, the likelihood of deformation of components, as under the influence of weight or heat, may be reduced.

Coordinated operation of all of the components of the machining system **10** can be carried out through a central controller **150**, which can be programmed and operated by a user from a control panel **152**.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A machining system comprising:

a first machine tool assembly comprising a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder;

a second machine tool assembly comprising a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder;

a base assembly on which the first and second machine tool assemblies are supported in an operative position and having a top and bottom,

at least a part of the first machine tool assembly being repositionable by movement along a first line,

at least a part of the second machine tool assembly being repositionable by movement along a second line that is non-parallel to the first line,

the parts of the first and second machine tool assemblies being relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies; and

an upwardly opening receptacle for collecting foreign matter,

wherein the base comprises a flat surface that is uninterrupted from a location adjacent to the first workpiece holder to a bottom edge of the base residing over the receptacle so that foreign matter removed from a workpiece at the first workpiece holder is guided by the flat surface over the bottom edge into the upwardly opening receptacle.

2. A machining system comprising:

a first machine tool assembly comprising a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder;

a second machine tool assembly comprising a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder; and

a base assembly on which the first and second machine tool assemblies are supported in an operative position,

at least a part of the first machine tool assembly being repositionable by movement along a first line,

at least a part of the second machine tool assembly being repositionable by movement along a second line that is non-parallel to the first line,

the parts of the first and second machine tool assemblies being relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies,

wherein the first machine tool assembly has a first central operating axis, the second machine tool assembly has a second central operating axis, the first line and a third line parallel to the first central operating axis reside in a first plane, the second line and a fourth line parallel to the second central operating axis reside in a second plane, and the first and second planes are non-parallel to each other.

3. The machining system according to claim **2** wherein the first and second planes define a downwardly opening angle of less than 135° therebetween.

4. The machining system according to claim **2** wherein the first and second planes define a downwardly opening angle on the order of 90°.

5. The machining system according to claim **1** wherein the first line extends at an angle to a horizontal reference plane.

6. The machining system according to claim **1** wherein the part of the first machine tool assembly comprises a first headstock, the part of the second machine tool assembly comprises a second headstock, each of the headstocks has a central axis and the first and second headstocks are relatively repositionable into a workpiece exchange position wherein the central axes of the first and second headstocks are substantially coincident.

7. A machining system comprising:

a first machine tool assembly comprising a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder;

a second machine tool assembly comprising a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder; and

a base assembly on which the first and second machine tool assemblies are supported in an operative position,

at least a part of the first machine tool assembly being repositionable by movement along a first line,

at least a part of the second machine tool assembly being repositionable by movement along a second line that is non-parallel to the first line,

the parts of the first and second machine tool assemblies being relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies,

wherein the part of the first machine tool assembly comprises a first headstock, the part of the second machine tool assembly comprises a second headstock, each of the headstocks has a central axis and the first and second headstocks are relatively repositionable into a workpiece exchange position wherein the central axes of the first and second headstocks are substantially coincident,

wherein the base assembly comprises first and second substantially flat surfaces cooperatively defining an inverted V shape, the first machine tool assembly is mounted on the first flat surface and the second machine tool assembly is mounted on the second flat surface.

8. A method of machining a workpiece, said method comprising the steps of:

performing a first processing operation on a first workpiece using a first machine tool assembly;

at the completion of the first processing operation, moving the first workpiece in a first line that extends in a direction at an angle to horizontal;

transferring the first workpiece to a second machine tool assembly;

performing a second processing operation on the first workpiece; and

moving the first workpiece along a second line that is non-parallel to the first line and extends in a direction at an angle to horizontal.

9. The machining system according to claim **7** wherein the base assembly further comprises an upwardly projecting support, the first flat surface has a width extending parallel to the central axis of the first headstock and the upwardly projecting support has a width dimension parallel to the central axis of the first headstock that is substantially less than the width of the first flat surface.

10. The machining system according to claim **1** wherein the first workpiece holder comprises a first headstock and the first machining unit comprises an indexable turret with a plurality of machining tools.

11. The machining system according to claim **10** wherein the first machine tool assembly further comprises a first conveyor for delivering workpieces to be processed to a transfer location.

12. The machining system according to claim **11** wherein the first machine tool assembly further comprises a first transfer mechanism to engage a workpiece on the first conveyor and deliver an engaged workpiece toward a position at which an engaged workpiece can be operatively held by the first headstock.

13. The machining system according to claim **12** wherein the machine tool assembly further comprises a second conveyor for delivering workpieces from the second workpiece holder to a point of use.

14. The machining system according to claim **13** wherein the second machine tool assembly comprises a second transfer mechanism to engage a workpiece on the second workpiece holder and deliver an engaged workpiece to the second conveyor.

15. The machining system according to claim **12** wherein the first transfer mechanism comprises first and second jaws that are relatively movable between a gripping position, to hold a workpiece, and a release position.

16. A machining system comprising:

a first machine tool assembly comprising a first workpiece holder and a first machining unit for performing a processing operation on a workpiece held by the first workpiece holder;

a second machine tool assembly comprising a second workpiece holder and a second machining unit for performing a processing operation on a workpiece held by the second workpiece holder; and

a base assembly on which the first and second machine tool assemblies are supported in an operative position,

at least a part of the first machine tool assembly being repositionable by movement along a first line,

at least a part of the second machine tool assembly being repositionable by movement along a second line that is non-parallel to the first line,

the parts of the first and second machine tool assemblies being relatively repositionable along the first and second lines to facilitate transfer of a workpiece between the first and second machine tool assemblies,

wherein the first machine tool assembly has a first central operating axis, the second machine tool assembly has a second central operating axis, the first line and a third line parallel to the first central operating axis reside in a first plane, the second line and a fourth line parallel to the second central operating axis reside in a second plane, and the first and second planes are non-parallel to each other,

wherein the first central operating axis extends in a horizontal direction.

17. A machining system comprising:

a first machine tool assembly comprising a first headstock for holding a workpiece on which a processing operation is to be performed;

a second machine tool assembly comprising a second headstock for holding a workpiece on which a processing operation is to be performed; and

a base assembly on which the first and second machine tool assemblies are supported in an operative position,

the first headstock being movable along two transverse axes residing in a first plane,

the second headstock being movable along two transverse axes residing in a second plane,

wherein the first and second planes are non-parallel to each other.

18. The machining system according to claim **17** wherein the first and second planes cooperatively define an inverted V shape.

19. The machining system according to claim **18** wherein the first and second planes open downwardly at an angle of less than 135°.

20. The machining system according to claim **18** wherein the first and second planes open downwardly at an angle on the order of 90°.

21. A machining system comprising:

a first machine tool assembly comprising a first headstock for holding a workpiece on which a processing operation is to be performed;

a second machine tool assembly comprising a second headstock for holding a workpiece on which a processing operation is to be performed; and

a base assembly on which the first and second machine tool assemblies are supported in an operative position,

the base assembly comprising a first substantially flat surface and a second substantially flat surface which is angularly oriented relative to the first flat surface so that first and second planes including the first and second flat surfaces define an inverted V shape,

the first machine tool assembly residing above the first flat surface so that at least one of a lubricant and pieces of a workpiece removed during processing using the first machine tool assembly are guided downwardly by the first surface,

the second machine tool assembly residing above the second flat surface so that at least one of a lubricant and pieces of a workpiece removed during processing using the second machine tool assembly are guided downwardly by the second surface.

22. The machining system according to claim 21 further comprising an upwardly opening receptacle to collect at least one of a lubricant and pieces of a workpiece removed during processing using the first machine tool assembly and guided downwardly by the first surface.

23. The machining system according to claim 22 wherein the first machine tool assembly comprises a first headstock for holding a workpiece, the second machine tool assembly comprises a second headstock for holding a workpiece, and the first and second headstocks are relatively repositionable so as to facilitate exchange of a workpiece between the first and second headstocks.

24. The machining system according to claim 23 wherein the first and second headstocks each have a central axis and are relatively repositionable into an exchange position wherein the central axes of the first and second headstocks are substantially coincident.

25. The machining system according to claim 24 wherein the first headstock is positionable in an operating position and the first headstock is movable in a first plane between the operating position and a position in which the first headstock resides with the first and second headstocks in the exchange position and the first plane is angularly oriented relative to a horizontal reference plane.

26. The machining system according to claim 25 wherein the second headstock is positionable in an operating position and the second headstock is movable in a second plane between the operating position for the second headstock and a position in which the second headstock resides with the first and second headstocks in the exchange position and the second plane is angularly oriented relative to the first plane and the horizontal reference plane.

27. The machining system according to claim 26 wherein the first and second planes cooperatively define an inverted V shape.

28. The method of machining a workpiece according to claim 8 further comprising the steps of advancing the first workpiece on a first conveyor toward a first headstock on the first machine tool assembly and through a first transfer mechanism engaging the first workpiece and delivering the engaged first workpiece to the first headstock.

29. The method of machining a workpiece according to claim 8 wherein the first and second lines cooperatively define an inverted V shape.

30. The method of machining a workpiece according to claim 8 further comprising the steps of directing at least one of a lubricant and pieces of the first workpiece removed during the first processing operation along a first inclined surface downwardly to a collection area.

31. The method of machining a workpiece according to claim 30 further comprising the step of collecting the at least one of lubricant and pieces of the first workpiece removed during the first processing operation in a receptacle.

32. The method of machining a workpiece according to claim 30 further comprising the steps of directing the at least one of lubricant and pieces of the first workpiece removed during the second processing operation along a second inclined surface downwardly to a collection area.

33. The method of machining a workpiece according to claim 32 wherein the first and second inclined surfaces cooperatively define an inverted V shape.

34. The method of machining a workpiece according to claim 8 wherein the step of transferring the first workpiece comprises repositioning at least one of a first headstock on the first machine tool assembly and a second headstock on the second machine tool assembly so that the first and second headstocks are in an exchange position and so that the first workpiece can be transferred directly from the first headstock to the second headstock.

35. The method of machining a workpiece according to claim 34 wherein the first and second headstocks each have a central axis and with the first and second headstocks in the exchange position the central axes of the first and second headstocks are substantially coincident.

36. The method of machining a workpiece according to claim 8 wherein the step of performing a first processing operation comprises performing a first processing operation using a tool on a first indexable turret.

37. The method of machining a workpiece according to claim 36 wherein the step of performing a second processing operation comprises performing a second processing operation using a tool on a second indexable turret.

38. The method of machining a workpiece according to claim 28 further comprising the steps of using a second transfer mechanism to remove the first workpiece from a second headstock on the second machine tool assembly and transferring the first workpiece to a second conveyor through which the first workpiece is advanced to a point of use.

* * * * *

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(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,637,306 B2**
(45) **Date of Patent: Oct. 28, 2003**

(54) **LATHE ASSEMBLY AND METHOD OF OPERATING THE LATHE ASSEMBLY**

(76) Inventor: **Toshiharu Tom Miyano**, c/o Miyano Machinery USA Inc., 940 N. Central Ave., Wood Dale, IL (US) 60191

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **10/237,838**

(22) Filed: **Sep. 9, 2002**

(65) **Prior Publication Data**

US 2003/0005799 A1 Jan. 9, 2003

Related U.S. Application Data

(62) Division of application No. 09/378,645, filed on Aug. 20, 1999, now Pat. No. 6,446,533.

(51) **Int. Cl.**[7] **B23B 13/00**; B23B 1/00

(52) **U.S. Cl.** **82/127**; 82/162; 82/170

(58) **Field of Search** 82/127, 117, 118, 82/120, 121, 126, 124, 129, 132, 133, 162, 165, 170, 173

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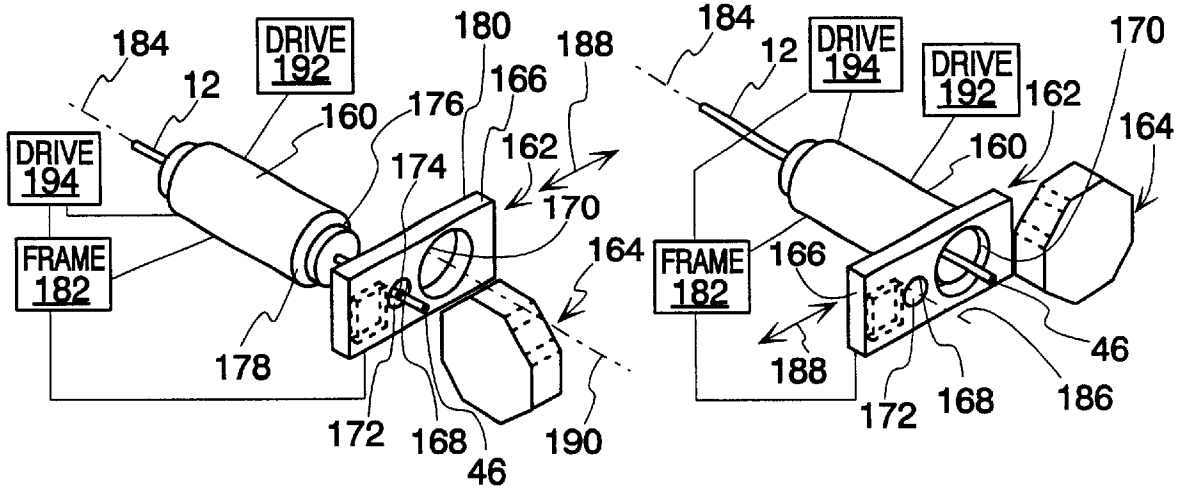
Primary Examiner—Henry W. H. Tsai
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A lathe assembly having a guide with a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position. A sensor assembly is capable of detecting the position of the trailing end of a piece of bar stock within the guide passageway to thereby allow a user to determine if a piece of bar stock in the guide passageway has a length sufficient to perform the desired operation thereon. Also, a method of using the lathe assembly.

21 Claims, 4 Drawing Sheets



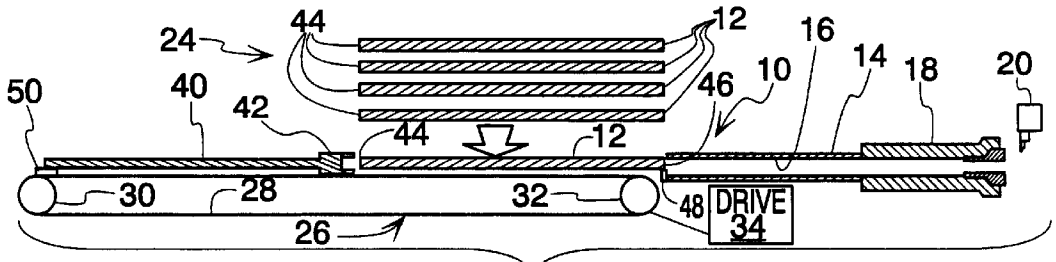


Fig. 1 (PRIOR ART)

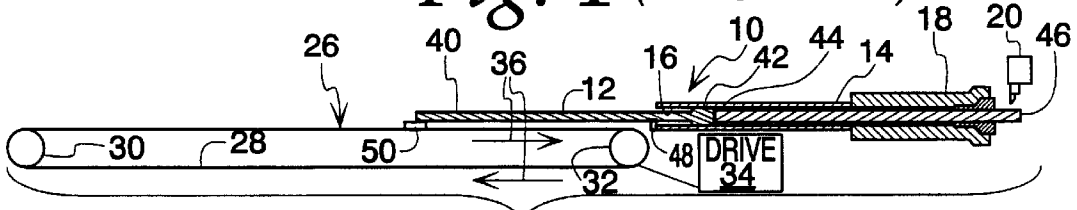


Fig. 2 (PRIOR ART)

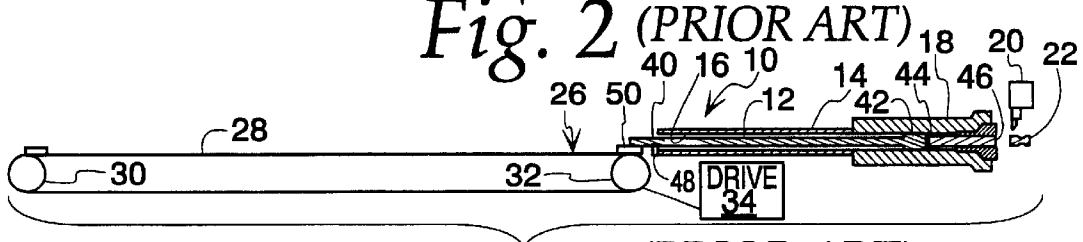


Fig. 3 (PRIOR ART)

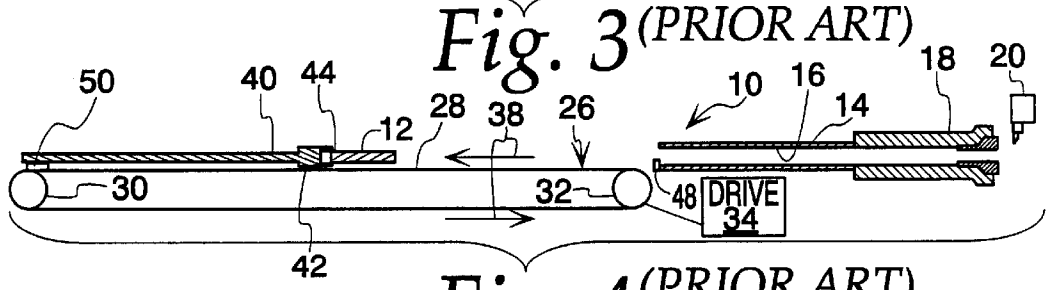


Fig. 4 (PRIOR ART)

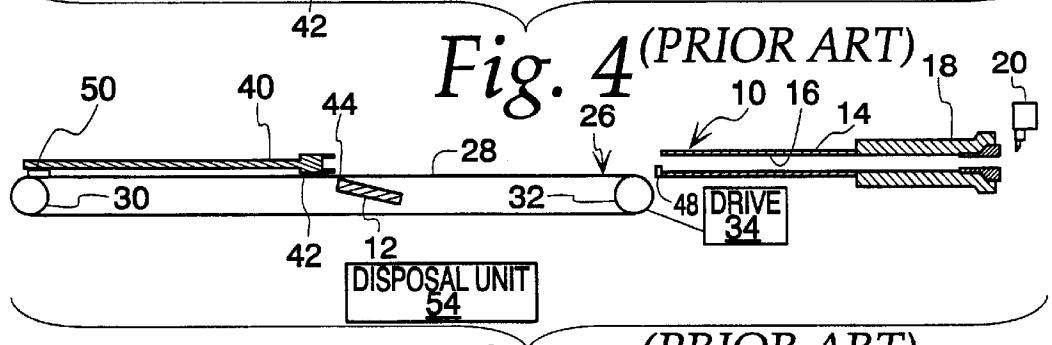
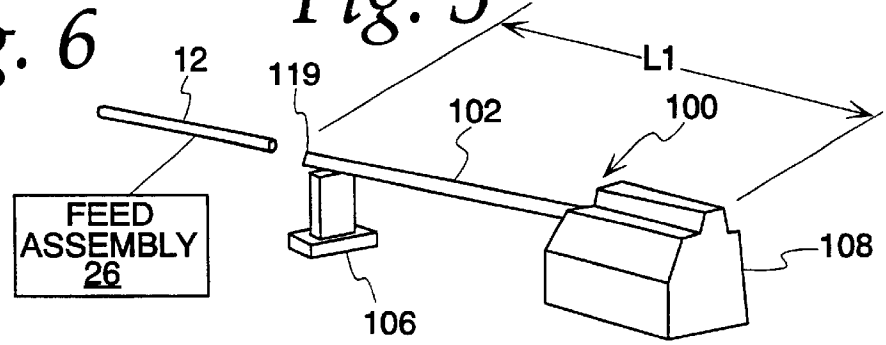


Fig. 5 (PRIOR ART)

Fig. 6



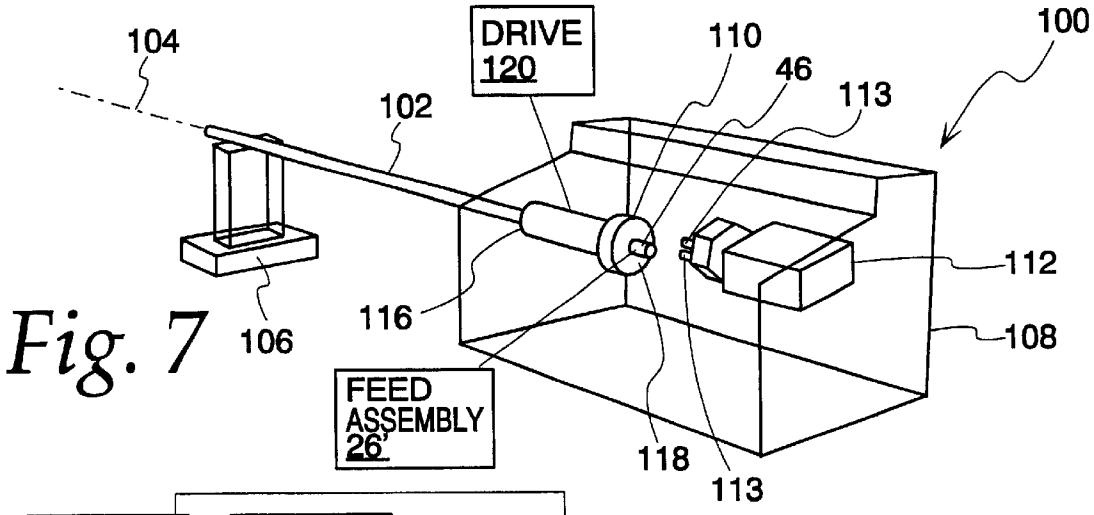


Fig. 7

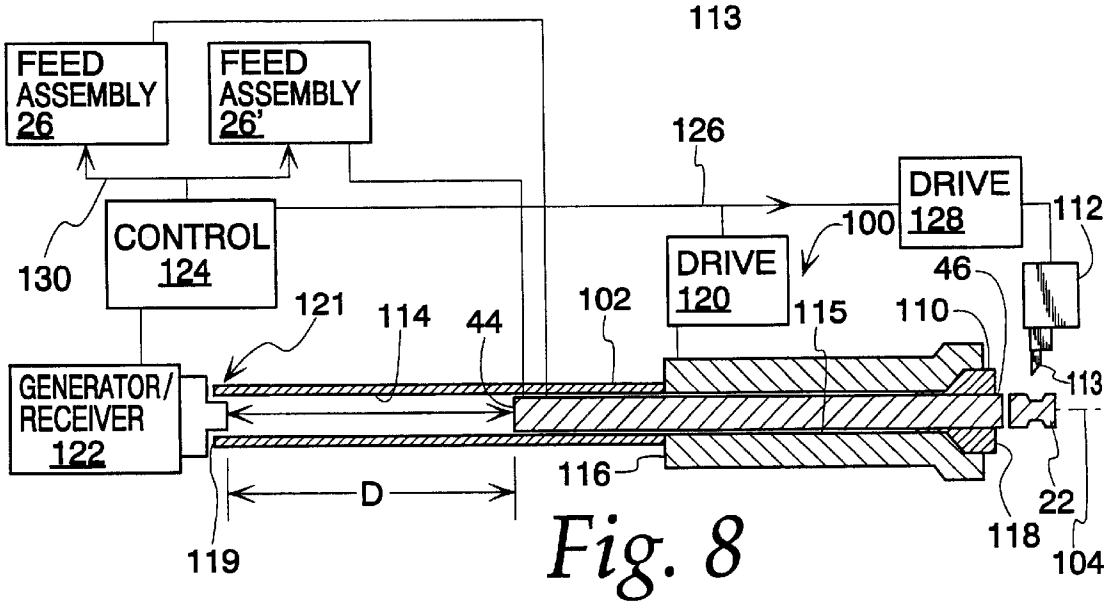


Fig. 8

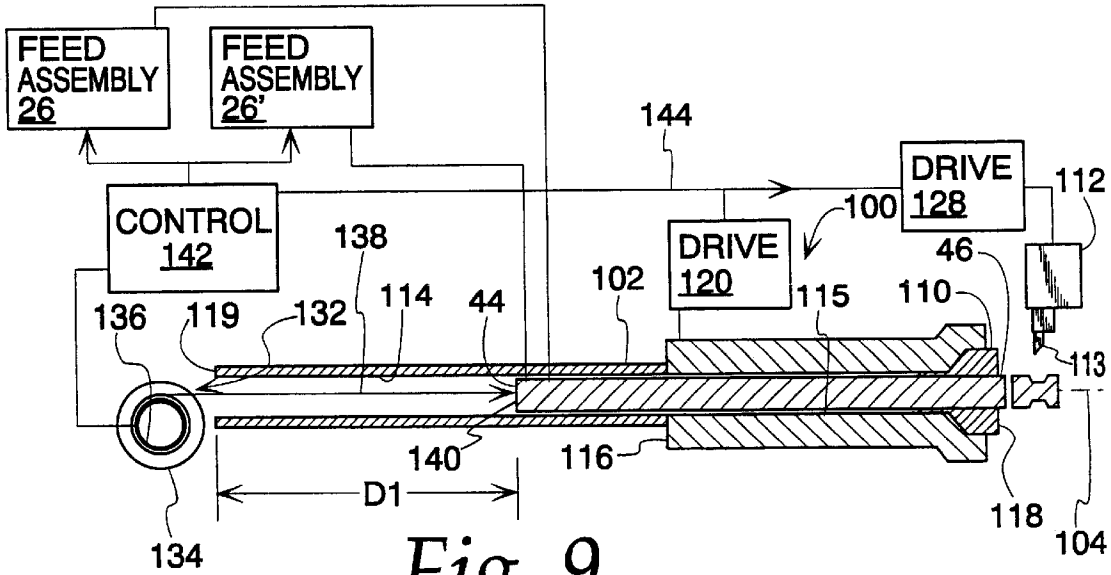


Fig. 9

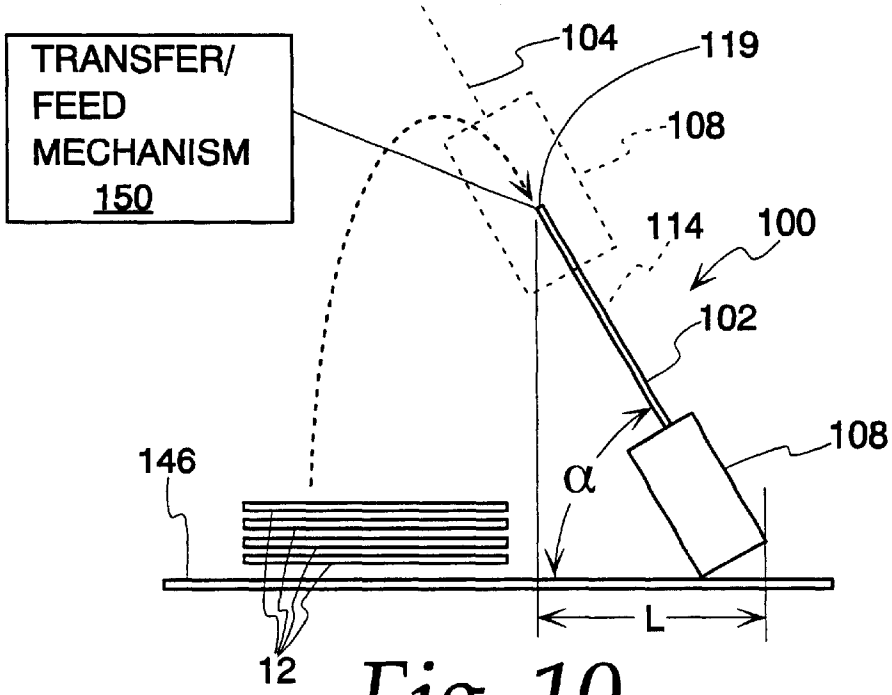

TRANSFER/
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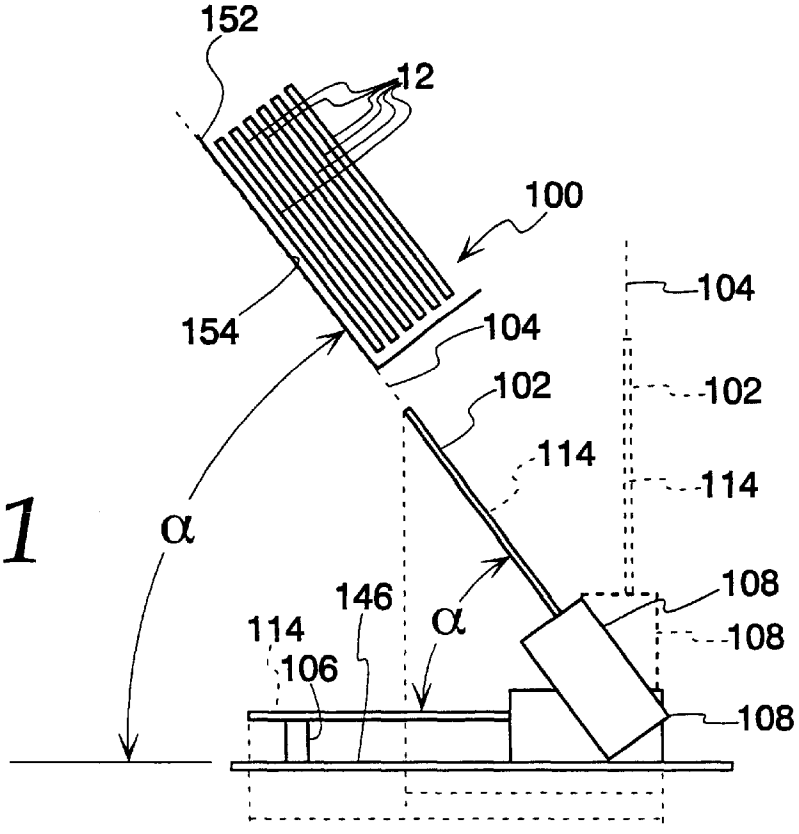
Fig. 10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106
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Fig. 11

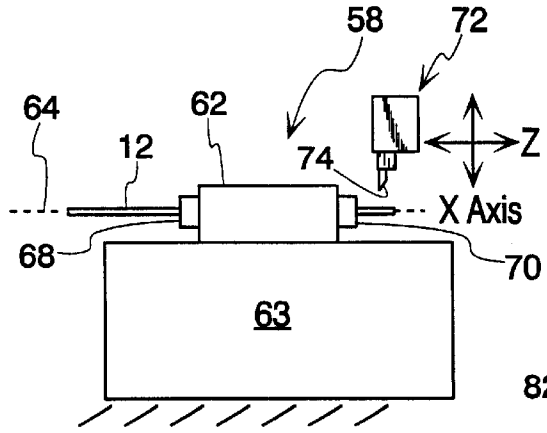

Fig. 12
(PRIOR ART)

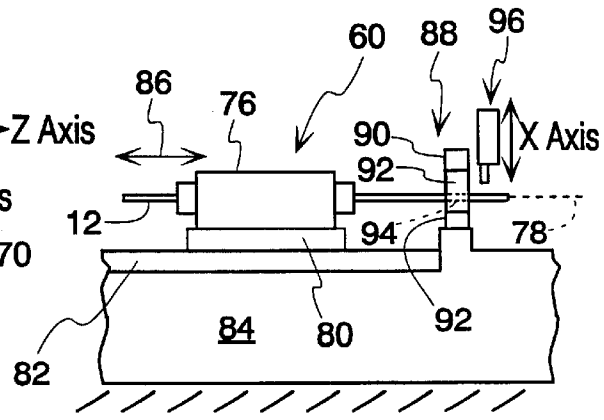

Fig. 13
(PRIOR ART)

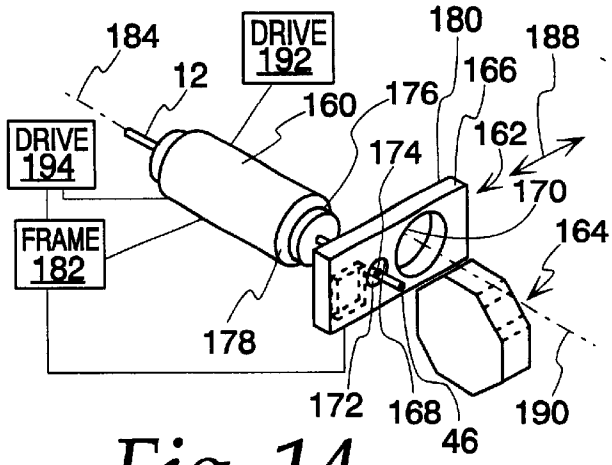

Fig. 14

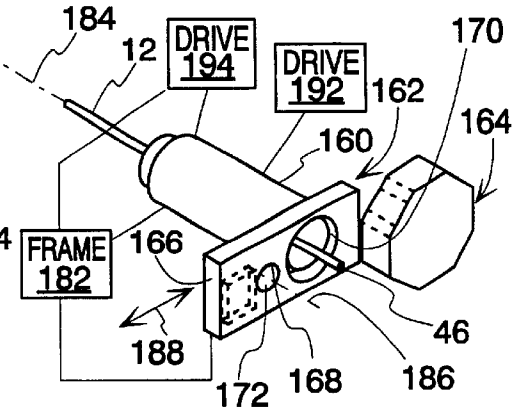

Fig. 15

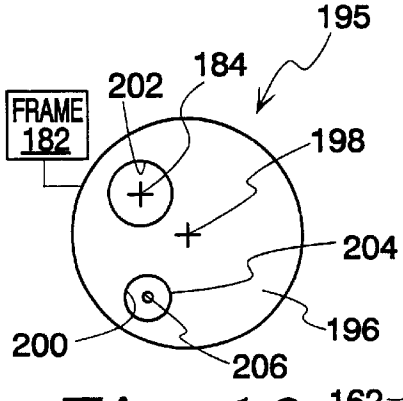

Fig. 18

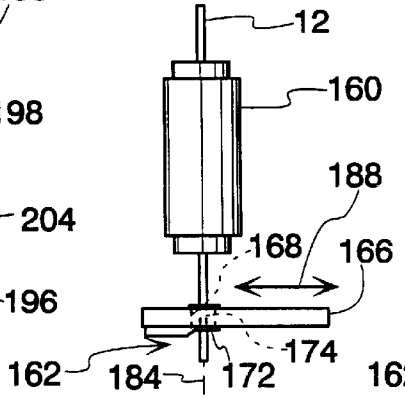

Fig. 16

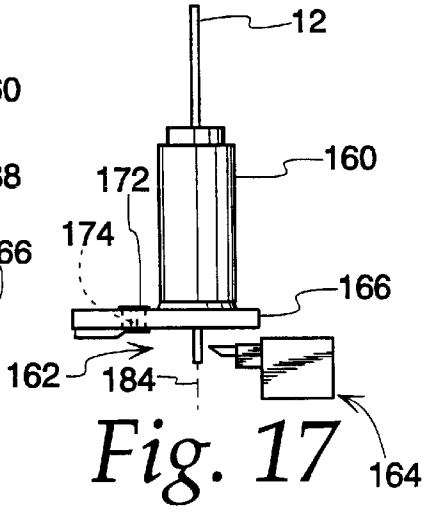

Fig. 17

LATHE ASSEMBLY AND METHOD OF OPERATING THE LATHE ASSEMBLY

CROSS-REFERENCE

This application is a division of application Ser. No. 09/378,645, filed Aug. 20, 1999, entitled "Lathe Assembly and Method of Using a Lathe Assembly", now U.S. Pat. No. 6,446,533.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to lathe assemblies and, more particularly, to a lathe assembly which performs a machining operation on a piece of bar stock. The invention is also directed to a method of using a lathe assembly.

2. Background Art

It is known to feed bar stock to a tool assembly and to machine the bar stock in successive machining operations to produce multiple, finished workpieces from a single piece of the bar stock. In FIGS. **1–5** herein, a conventional lathe assembly is shown at **10** for operating in this manner upon individual pieces **12** of bar stock.

The lathe assembly **10** consists of a guide **14** defining a passageway **16** within which the individual pieces **12** of bar stock can be guidingly moved selectively towards and away from a spindle **18**. Through the spindle **18**, the pieces **12** of bar stock can be held in a working position, as shown in FIG. **2**, and rotated. A tool assembly **20** performs machining operations on the pieces **12** of bar stock in the working position to produce individual workpieces **22**.

The pieces **12** of bar stock are delivered to the passageway **16** from a supply location at **24** through a feed assembly **26**. The feed assembly **26** consists of an endless chain conveyor **28** which is trained around spaced pulleys **30**, **32**. Through a drive **34**, the pulley **32** is rotated selectively in a forward direction, as indicated by the arrows **36** in FIG. **2**, and a reverse direction, as indicated by the arrows **38** in FIG. **4**.

A push rod **40** is attached to the upper surface of the chain conveyor **28** and is movable from left to right, with the drive **34** operated to rotate the pulley **32** in the forward direction, and from right to left, with the drive **34** operated to rotate the pulley **32** in the reverse direction. The push rod **40** has a receiver **42** at an end thereof to grip the trailing ends **44** of the pieces **12** of bar stock.

In operation, the pieces **12** of bar stock are delivered one-by-one from the supply location **24** to the top surface of the chain conveyor **28** with the push rod **40** retracted to the FIG. **1** position. The drive **32** is then activated to rotate the pulley **32** in the forward direction which causes the receiver **42** to advance from left to right and engage the trailing end **44** of the active piece **12** of bar stock. Continued operation of the drive **34** causes the leading end **46** of the active piece **12** of bar stock to be directed into and through the passageway **16** and spindle **18** to be exposed outside of the spindle **18**, as shown in FIG. **2**, for operation thereon by the tool assembly **20** to thereby produce a workpiece **22**.

The drive **34** is incrementally operated to advance the active piece **12** of bar stock a distance equal to a predetermined length dimension for the workpiece **22**. Eventually, the length of the active piece **12** of bar stock is diminished to less than the predetermined length of the workpiece **22** that is to be produced. Attempting to machine the remaining piece **12** of bar stock that is shorter than the predetermined length of the workpiece **22** could cause jamming and, in any event, is a wasted step given that the machined workpiece **22** would have to be sorted and discarded.

To avoid the above situation, it is known to use a proximity sensor **48** which detects an element **50** at the trailing end **44** of the active piece **12** of bar stock. The element **50** is strategically situated so that the proximity sensor **48** detects the element **50** once the active piece **12** of bar stock has been reduced to a length less than that necessary to form the workpiece **22**. After the last possible workpiece **22** is formed, the sensor detects the element **50** and causes a signal to be generated that causes the drive **32** to thereby retract the remaining piece **12** of bar stock from the passageway **16** and release it to a disposal unit **54**, as shown in FIG. **5**.

The horizontal arrangement of the guide **14** is typical of conventional lathe assemblies. One problem with this horizontal arrangement is that, with very long workpieces, a significant amount of floor space may be required to operate the lathe assembly.

While it is known to vertically orient elongate workpieces held in a vertically opening chuck on lathe assemblies, the problem of chip buildup on the workpiece and chuck must be contended with.

In FIGS. **12** and **13**, two additional prior art lathe assemblies are shown at **58** and **60**, respectively. The lathe assembly **58** is characterized as a fixed spindle lathe assembly with there being a spindle **62** thereon, fixedly attached to a frame **63** and having a horizontal central axis **64**. An elongate piece **12** of bar stock is advanced from an input end **68** of the spindle **62** through the spindle **62** to and through an output end **70** at which the piece **12** of bar stock is exposed to be machined by a tool assembly **72**. The tool assembly **72** is selectively movable along X and Z axes to allow a tool element **74** on the tool assembly **72** to operate on the piece **12** of bar stock held and rotated by the spindle **62**.

The lathe assembly **60** is characterized as a sliding spindle lathe assembly and includes a spindle **76** with a horizontal central axis **78**. The spindle **76** has an adaptor **80** which cooperates with, and is guided along, a rail **82** on a frame **84** so as to allow the spindle **76** to move in the line of the double-headed arrow **86** parallel to the central axis **78** of the spindle **76**.

In the lathe assembly **60**, a bushing assembly **88** is provided with a body **90** and a bushing **92** having an opening **94** therethrough. The spindle axis **78** is coincident with the central axis for the bushing opening **94**. The bushing assembly **88** serves as a support to rigidify the end of the piece **12** of bar stock that is being machined by a tool assembly **96**.

Typically, both of the lathe assemblies **58**, **60** are designed for relatively small diameter pieces **12** of bar stock. It is conventional to make dedicated machines that function either as a fixed spindle lathe assembly, such as the lathe assembly **58**, or as a sliding spindle lathe assembly, such as the lathe assembly **60**.

SUMMARY OF THE INVENTION

The invention is directed to a lathe assembly having a guide with a passageway for movement of a piece of bar stock, with a leading end and a trailing end, in a substantially straight path between a feeding position and a working position. A sensor assembly is capable of detecting the position of the trailing end of a piece of bar stock within the guide passageway to thereby allow a user to determine if a piece of bar stock in the guide passageway has a length sufficient to perform a desired operation thereon.

The lathe assembly may further include a spindle for releasably holding a piece of bar stock in the working position.

The sensor assembly may have a generator for a signal indicative that a piece of bar stock in the guide passageway has less than a predetermined length.

The lathe assembly may further include a tool assembly to perform an operation on a piece of bar stock in the working position.

The sensor assembly may include a generator for a stop signal indicative that a piece of bar stock in the guide passageway has less than the predetermined length. The lathe assembly may further include a control to receive the stop signal and, in response thereto, prevent performance of an operation by the tool assembly on a piece bar stock in the passageway.

The sensor assembly may include an elongate element that can be directed into the guide passageway to against the trailing end of a piece of bar stock in the passageway to thereby determine whether a piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The sensor assembly may include a generator for a beam to be directed against the trailing end of a piece of bar stock in the guide passageway and reflected therefrom and a receiver for the reflected beam.

The generator may be a laser beam generator.

The lathe assembly may further include a piece of bar stock in the guide passageway.

The lathe assembly may still further include a drive to rotate a piece of bar stock in the working position in the guide passageway.

The tool assembly may include a tool element which acts against a piece of bar stock in the working position. The tool assembly may include a turret with a plurality of inter-changeable tool elements.

In one form, the spindle has an axis and axially spaced input and output ends and the piece of bar stock in the working position projects from both the input and output ends of the spindle.

In one form, the passageway has a central axis and axially spaced first and second ends. The spindle is at the first axially spaced end and the second axially spaced end is open to allow introduction of a piece of bar stock into the guide passageway.

The invention is also directed to a method of operating a lathe assembly having a guide with a passageway with a central axis and axially spaced first and second ends, a spindle, and a tool assembly for performing an operation on a piece of bar stock having a length and leading and trailing ends. The method includes the steps of directing a piece of bar stock axially through the guide passageway in a first direction from a feeding position into a working position and directing an element into the guide passageway to detect the position of the trailing end of the piece of bar stock and thereby determine if the piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The method may further include the step of performing an operation on the piece of bar stock with the tool assembly if it is determined that the piece of bar stock has at least the predetermined length.

The method may further include the step of advancing the piece of bar stock in the first direction after performing the operation and again directing the element into the guide passageway to detect the position of the trailing end of the piece of bar stock to again determine if the piece of bar stock in the guide passageway is less than or greater than the predetermined length.

The step of directing an element from the sensor into the guide passageway may involve the step of directing a laser beam into the guide passageway.

The step of directing an element from the sensor into the guide passageway may involve the step of directing an elongate element into the guide passageway.

The method may further include the steps of providing a sensor assembly, generating a stop signal from the sensor assembly indicative that the piece of bar stock has a length less than the predetermined length, and processing the stop signal so that no operation is performed by the tool assembly on the piece of bar stock in the guide passageway.

The invention is also directed to a lathe assembly with a guide having a passageway with a central axis for movement of a piece of bar stock with a leading end and trailing end in a substantially straight path substantially parallel to the central axis of the passageway between a feeding position and a working position, and a spindle for releasably holding a piece of bar stock in the working position and having a through opening with a central axis, an input end, and an output end. The guide is oriented so that the central axis of the passageway is not parallel to a horizontal support surface for the lathe assembly. The passageway and through opening are aligned so that the leading end of a piece of bar stock can move through the passageway to and through the through opening from the input end to the output end to project from the output end with a piece of bar stock in the working position.

The central axes of the passageway and through opening may be substantially parallel to each other and extend substantially orthogonally to a horizontal support surface for the lathe assembly.

In one form, the central axes of the passageway and through opening are substantially parallel to each other and are non-orthogonal to a horizontal support surface for the lathe assembly.

The lathe assembly may further include a tool assembly for performing an operation on a piece of bar stock in the working position.

The invention is also directed to a method of operating a lathe assembly with a guide having a passageway with a central axis and axially spaced first and second ends, a spindle with a through opening having a central axis, an input end and an output end, and a tool assembly for performing an operation on a piece of bar stock having a length, a leading end, and a trailing end. The method includes the steps of orienting the guide so that the central axis of the passageway is inclined relative to a horizontal support surface for the lathe assembly and so that the central axis of the passageway declines from the first end towards the second end of the passageway, directing the leading end of the piece of bar stock into and through the passageway in a first direction from the first end of the passageway towards the second end of the passageway, moving the leading end of the piece of bar stock in the first direction into and through the through opening to a working position wherein the leading end of the bar stock projects from the output end of the spindle, clamping the piece of bar stock in the working position in the spindle, and performing an operation on a portion of the piece of bar stock projecting from the output end of the through opening with the piece of bar stock in the working position.

The method may further include the steps of placing a plurality of pieces of bar stock, each having a length, in a storage position, with the lengths of the plurality of pieces of bar stock being substantially parallel to each other and

substantially parallel to a horizontal surface supporting the lathe assembly, removing the plurality of workpieces of bar stock one-by-one from the storage position, and directing the plurality of pieces of bar stock one-by-one into the passageway.

The method may further include the steps of placing a plurality of pieces of bar stock each having a length in a storage position with the lengths of the plurality of pieces of bar stock being substantially parallel to each other and substantially non-parallel to a horizontal surface supporting the lathe assembly, removing the plurality of pieces of bar stock one-by-one from the storage position, and directing the plurality of pieces of bar stock one-by-one into the passageway.

The invention is further directed to a lathe assembly having a spindle for holding an elongate workpiece and having a central axis, and a guide assembly having a body and a guide bushing on the body having a first opening with a central axis. The spindle and guide assembly are selectively repositionable between a) a first relative position wherein the central axis of the spindle extends through the first guide bushing opening so that an elongate workpiece held by the spindle can be projected into the first guide bushing opening so that the guide bushing limits flexing of an elongate workpiece held by the spindle and b) a second relative position wherein the central axis of the spindle does not extend through the first guide bushing opening. The lathe assembly further includes a tool assembly for performing an operation on an elongate workpiece held by the spindle.

In one form, with the spindle and guide assembly in the first relative position, the central axis of the spindle is substantially coincident with the central axis of the first guide bushing opening.

The guide bushing may be rotatable relative to the guide assembly body around the central axis of the first guide bushing opening.

The lathe assembly may further be provided in combination with an elongate workpiece that is held by the spindle and projects into the first guide bushing opening with the spindle and guide assembly in the first relative position.

In one form, the guide assembly has a second opening in the body with a central axis and with the spindle and the guide assembly in the second relative position, the central axis of the spindle extends through the second opening.

In one form, the first guide bushing opening has a first diameter, and the second opening has a second diameter, and the first diameter is different than the second diameter.

The guide assembly may be translatable relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

The guide assembly may be rotatable about an axis relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

The spindle and guide assembly may be movable, one relative to the other, along a line substantially parallel to the central axis of the spindle.

In one form, the spindle is abuttable to the guide assembly to be supported by the guide assembly.

In one form, with the spindle and the guide assembly in the second relative position, the central axis of the spindle is substantially coincident with the central axis of the second opening.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic, cross-sectional view of a prior art lathe assembly including a feed assembly for directing pieces of bar stock through a guide passageway to a spindle to be held thereby for operation by a tool assembly and with one of the pieces of bar stock placed on the feed assembly;

FIG. **2** is a view as in FIG. **1** with the feed assembly operated to advance the piece of bar stock through the guide passageway and spindle to a working position wherein it is exposed to be machined by the tool assembly;

FIG. **3** is a view as in FIG. **2** showing the piece of bar stock further advanced and with a workpiece formed and cut from the end of the piece of bar stock;

FIG. **4** is a view as in FIG. **3** wherein the feed assembly is operated to withdraw the remaining portion of the piece of bar stock from the spindle and guide passageway;

FIG. **5** is a view as in FIG. **4** with the remaining piece of bar stock being deposited in a disposal unit;

FIG. **6** is a schematic, perspective view of a lathe assembly according to the present invention;

FIG. **7** is a view as in FIG. **6** showing a spindle and tool assembly on the lathe assembly;

FIG. **8** is an enlarged, schematic, cross-sectional view of a guide defining a passageway, spindle, and a tool assembly for repositioning and advancing a piece of bar stock for operation thereon by a tool assembly on the inventive lathe assembly of FIGS. **6** and **7** and showing one type of structure, according to the present invention, for determining the remaining length of a piece of bar stock in the guide passageway;

FIG. **9** is a view as in FIG. **8** showing another form of structure for determining the remaining length of a piece of bar stock in the guide passageway;

FIG. **10** is a schematic representation of a lathe system, according to the invention, and having a non-horizontal guide passageway for a supply of pieces of bar stock, with the individual pieces being deliverable one-by-one from a supply in which the elongate bar stock is situated horizontally;

FIG. **11** is a view as in FIG. **10** with pieces of bar stock in a supply situated angularly to a horizontal support surface for the lathe assembly for facilitated delivery to the guide passageway, and with a modification of the lathe assembly shown in phantom wherein the guide assembly extends substantially orthogonally to a horizontal support surface for the lathe assembly;

FIG. **12** is a schematic, side elevation view of a conventional lathe assembly having a fixed spindle;

FIG. **13** is a side elevation view of a conventional lathe assembly having a slidable spindle;

FIG. **14** is a perspective view of a spindle in relationship to a guide assembly, according to the invention, and a tool assembly, with the guide assembly and spindle being in a first relative position wherein a piece of bar stock held by the spindle is supported on a bushing on the guide assembly;

FIG. **15** is a view as in FIG. **14** with the spindle and guide assembly repositioned to a second relative position wherein the spindle abuts to the guide assembly and the piece of bar stock is not directly supported by the guide assembly;

FIG. **16** is a fragmentary, plan view of the spindle and guide assembly, according to the invention, arranged to function as a fixed spindle lathe assembly as in FIG. **14**;

FIG. **17** is a fragmentary, plan view of the spindle and guide assembly, according to the invention, arranged to function as a sliding spindle lathe assembly as in FIG. **15**; and

FIG. **18** is an elevation view of a modified form of guide assembly that is useable in conjunction with the spindle in FIGS. **14–17**.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring initially to FIGS. **6–9**, a lathe assembly, according to the present invention, is shown at **100**. The lathe assembly **100** includes an elongate guide **102** with a central axis **104**. The guide **102** is supported by axially spaced frame elements **106**, **108**, with the latter defining a housing for a spindle **110** and a tool assembly **112**, which are operable to perform a machining operation on a piece **12** of bar stock held by the spindle **110**. The tool assembly **112** is a turret-type having interchangeable, and selectively usable, tool elements **113**.

The guide **102** defines a passageway **114** through which pieces **12** of bar stock can be delivered from a feeding position, as shown in FIG. **6**, in a straight path to a working position, as shown in FIGS. **7–9**. The spindle **110** has a through opening **115** with an input end **116** and an output end **118**. The through opening **115** and passageway **114** have coincident central axes. As a piece **12** of bar stock is moved from the feeding position into the working position, the leading end **46** thereof initially enters the passageway **114** at an open axial end **119** thereof, extends along the axis **104** up to and beyond the input end **116** of the spindle **110**, through the spindle **110** and from the output end **118** of the spindle **110** to be exposed adjacent to the tool assembly **112**. The advancement of the piece **12** of bar stock can be effected by a pushing action through the feed assembly **26**, as previously described with respect to claims **1–5**, or by a feed assembly **26'** which grips and pulls the pieces **12** of bar stock from the feeding position into the working position. The spindle **110** may be of any conventional construction.

Once in the working position, the active piece **12** of bar stock is held by the spindle **110** whereupon the appropriate machining operation is carried out by the tool assembly, as the spindle is rotated by a drive **120** around the axis **104**, to produce the finished workpiece **22**. The initial length of the pieces **12** of bar stock can be selected to allow fabrication of numerous of the workpieces **22** from each length thereof. Accordingly, after each machining operation, the feed assembly **26**, **26'** can be operated to advance the active piece **12** of bar stock a set distance as dictated by the length of the workpiece **22** to be formed.

According to the invention, the trailing end **44** of a piece **12** of bar stock is monitored to thereby determine whether the remaining length of the piece **12** of bar stock in the guide passageway **114** is sufficient to perform a desired operation thereon by the tool assembly **112**.

To accomplish this, a first type of sensor assembly is shown at **121**. The sensor assembly **121** includes a laser beam generator and receiver **122** which is capable of directing a laser beam at the trailing end **44** of a piece **12** of bar stock and receiving the reflected beam signal. With an appropriate control **124**, an analysis of the impinging and reflecting beams can be made, after each advancing movement of the piece **12** of bar stock, to ascertain the distance D between the laser beam generator/receiver **122** and the trailing end **44** of the piece **12** of bar stock. For a predetermined distance D, the remaining length of the active piece **12** of bar stock will be insufficient to perform an operation to produce a desired workpiece configuration. Upon identifying this predetermined distance, or greater, the control **124** sends a stop signal **126** to a drive **128** for the tool assembly **112** and/or the drive **120** to thereby prohibit operation of the tool assembly **112** on the remaining piece **12** of bar stock. At the same time, or alternatively, the control **124** may send a signal **130** to the feed assemblies **26**, **26'** which may cause the feed assemblies **26**, **26'** to stop and/or reverse the direction of movement of the remaining piece **12** of bar stock.

In FIG. **9**, an alternative form of sensor assembly is shown at **132**. The sensor assembly **132** includes a drum **134** with a hub **136** around which a wire element **138** is wrapped. The wire element **138** has a free end **140** which can be advanced into the passageway **114** by rotation of the hub **136**. The wire element **138** may be a single wire or a plurality of bundled wires. The wire may be spring wire, piano wire, or the like. The degree of rotation/number of rotations dictates the extension of the wire element **138** within the passageway **114** to allow calculation of the distance D1, which again is correlated to the length of the remaining piece **12** of bar stock.

The rotation of the hub **136** can be detected by a control **142**. Upon sensing the number of revolutions of the hub **136** which extends the wire element to a distance D1 indicative that the length of the remaining piece **12** of bar stock is less than that necessary to produce the desired configuration for the workpiece **22**, the control **142** generates a signal **144** to the drive **128** and/or one or both of the feed assemblies **26**, **26'**, as previously described.

In FIGS. **10** and **11**, the guide **102** and frame element **108** are shown inclined from the orientation in FIGS. **6–9** relative to a horizontal support surface **146** for the lathe assembly **100**. Whereas the central axis **104** is substantially parallel to the support surface **146** for the lathe assembly **100** in FIGS. **6–9**, in FIGS. **10** and **11**, the axis **104** makes an angle α to the support surface **146**. The angle α may range from a few degrees to 90°, as shown in dotted lines in FIG. **11**.

The effective length L occupied by the guide **102** and frame **108** is reduced from the length L1 (FIG. **6**) with the lathe assembly **100** in the FIG. **6** orientation. Since many facilities in which the lathe assembly **100** would be operated have no significant height restriction, it is possible to reduce the operating area of the floor required for the lathe assembly **100** by angularly situating the guide **102** and housing **108** as in FIGS. **10** and **11**.

In FIG. **10**, the pieces **12** of bar stock are stacked so that the lengths thereof are substantially parallel to each other and the surface **146**. Through an appropriate transfer/feed mechanism **150**, individual pieces **12** of bar stock can be reoriented and directed into the passageway **114** through the open axial end **119** of the guide **102**.

Alternatively, as shown in FIG. **11**, a hopper **152** can be provided for a supply of the pieces **12** of bar stock. The hopper **152** has a guide surface **154** which is situated at an angle α equal to the angle α for the inclination of the guide **102** and frame element **108**. Suitable structure can be provided to discharge the pieces **12** of bar stock one-by-one from the hopper **152** by movement along the guide surface **154**.

A further modification is shown in phantom lines in FIG. **10** wherein the lathe assembly **100** is reversed so that the frame element **108** is above the guide **102**. The individual pieces **12** of bar stock would thus have to be fed against gravitational forces to a working position. This arrangement may be practical at relatively small angles α and for relatively short pieces **12** of bar stock.

In FIGS. **14–17**, a spindle **160** is shown in conjunction with a guide assembly **162** which allows the tool assembly at **164** to perform a machining operation on the piece **12** of bar stock held by the spindle **160** both unsupported, with the fixed spindle arrangement as shown for the lathe assembly **58**, and supported with the sliding spindle arrangement, as shown for the lathe assembly **60**. Typically, this type of lathe assembly is used to produce small diameter parts using bar

stock on the order of ⅛–¼ inch as opposed to 3–4 inches for the lathe assembly **100**.

More specifically, the guide assembly has a body **166** with a mounting opening **168** and a second opening **170** therethrough. The mounting opening **168** has a bushing **172** fit therewithin and in turn has an opening **174** therethrough that is slightly greater in diameter than the diameter of the piece **12** of bar stock and of a lesser diameter than the second opening. The second opening **170** is dimensioned to snugly receive a reduced diameter portion **176** of the spindle **160**. With the reduced diameter portion **176** extended into the second opening **170**, an annular surface **178** abuts to a facing surface **180** on the body **166**.

According to the invention, the spindle **160** and body **166** are mounted to a frame **182** for guided movement between a first relative position, as shown in FIG. **14**, and a second relative position as shown in FIG. **15**. In the first relative position, the axis **184** of the spindle **160** extends through the opening **174** and is coincident with the central axis **186** of the opening **174** and the central axis of the piece **12** of bar stock held by the spindle **160**. The bushing **172**, which may be journalled for rotation relative to the body **166**, supports the leading end **46** of the piece **12** of bar stock near the location where it is operated upon by the tool assembly **164**.

By translatingly shifting one or both of the spindle **160** and body **166** relative to the frame **182**, and each other, in the direction of the double-headed arrow **188**, the spindle **160** and guide assembly **162** can be placed in the second relative position, wherein the central axis **184** extends through the opening **170** and coincides with the central axis **190** of the second opening **170**. In the second relative position, the annular surface **178** can be abutted to the surface **180**. The diameter of the second opening **170** is significantly greater than the diameter of the piece **12** of bar stock so that the spindle **160** can be rotated by a drive **192** without there being any interference between the piece **12** of bar stock and the body **166**.

In the first relative position of FIG. **14**, the spindle **160** and tool assembly **164** cooperate in the same manner as the spindle **76** and tool assembly **96** in FIG. **13**. In the second relative position of FIG. **15**, the spindle **160** and tool assembly **164** cooperate in the same manner as the tool assembly **62** cooperates with the tool assembly **72** in FIG. **12**. Thus, it is possible to use a single spindle **160** and a single lathe assembly to operate in both modes disclosed in FIGS. **12** and **13**.

A second drive **194** may also be used to move the spindle **160** relative to the frame **182** along the axis **184**. Additionally, or alternatively, the guide assembly **162** can be moved in the same line relative to the frame **182** and spindle **160**.

In FIG. **18**, a modified form of guide assembly **195** is shown having a body **196** which is rotatable around an axis **198** relative to the frame **182** and spindle **160** between corresponding first and second relative positions.

The body **196** has mounting and second openings **200**, **202** therethrough. By rotating the body **196** about the axis **198**, the openings **200**, **202** can be repositioned so that the central axes thereof selectively can be brought into coincidence with the axis **184**. The second opening **202** has the same diameter as the opening **170**, with the mounting opening **200** having a corresponding diameter to the first opening **168**. A like bushing **204** can be mounted in the opening **200** and in turn has an opening **206**, corresponding to the opening **174**, to accept the piece **12** of stock material.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A lathe assembly comprising:

a spindle for holding an elongate workpiece and having a central axis;

a guide assembly having a body and a guide bushing on the body having a first opening with a central axis,

the spindle and guide assembly being selectively repositionable between a) a first relative position wherein the central axis of the spindle extends through the first guide bushing opening so that an elongate workpiece held by the spindle can be projected into the first guide bushing opening so that the guide bushing limits flexing of an elongate workpiece held by the spindle and b) a second relative position wherein the central axis of the spindle does not extend through the first guide bushing opening and extends through the guide assembly at a location spaced from the first guide bushing opening; and

a tool assembly for performing an operation on an elongate workpiece held by the spindle with the spindle and guide assembly in each of the first and second relative positions.

2. The lathe assembly according to claim **1** wherein with the spindle and guide assembly in the first relative position the central axis of the spindle is substantially coincident with the central axis of the first guide bushing opening.

3. The lathe assembly according to claim **1** wherein the guide bushing is rotatable relative to the guide assembly body around the central axis of the first guide bushing opening.

4. The lathe assembly according to claim **1** in combination with an elongate workpiece that is held by the spindle and projects into the first guide bushing opening with the spindle and guide assembly in the first relative position.

5. The lathe assembly according to claim **1** wherein the guide assembly comprises a second opening in the body with a central axis, and with the spindle and the guide assembly in the second relative position the central axis of the spindle extends through the second opening.

6. The lathe assembly according to claim **5** wherein the first guide bushing opening has a first diameter, the second opening has a second diameter, and the first diameter is different than the second diameter.

7. The lathe assembly according to claim **5** wherein the guide assembly is translatable as one piece relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

8. The lathe assembly according to claim **5** wherein the guide assembly is rotatable as one piece about an axis relative to the spindle as the spindle and guide assembly are repositioned between the first relative position and the second relative position.

9. The lathe assembly according to claim **5** wherein with the spindle and the guide assembly in the second relative position the central axis of the spindle is substantially coincident with the central axis of the second opening.

10. The lathe assembly according to claim **1** wherein the spindle and guide assembly are movable, one relative to the other, along a line substantially parallel to the central axis of the spindle.

11. The lathe assembly according to claim **1** wherein the spindle is abuttable to the guide assembly to be supported by the guide assembly.

12. A lathe assembly comprising:

a spindle for holding an elongate workpiece and having a central axis;

a guide assembly having a body and a first opening with a central axis,

the spindle and guide assembly being selectively repositionable between a) a first relative position wherein the central axis of the spindle extends through the first opening so that an elongate workpiece held by the spindle can be projected into the first opening so that the guide assembly limits flexing of the elongate workpiece held by the spindle and b) a second relative position wherein the central axis of the spindle does not extend through the first opening and extends through the guide assembly at a location spaced from the first guide bushing opening; and

a tool assembly for performing an operation on the elongate workpiece held by the spindle with the spindle and guide assembly in each of the first and second relative positions.

13. A method of performing operations on elongate workpieces held by a spindle that is rotatable around a central axis, said method comprising the steps of:

directing a first elongate workpiece held by the spindle through a first guide opening on a guide assembly so that the guide assembly limits flexing of the first elongate workpiece;

performing an operation on the first elongate workpiece held by the spindle;

relatively repositioning the spindle and guide assembly by moving the guide assembly as one piece relative to the spindle; and

after relatively repositioning the spindle and guide assembly, performing another operation on one of a) the first elongate workpiece and b) a second elongate workpiece held by the spindle with the one of the first and second elongate workpieces passing through the guide assembly at a location spaced from first guide opening in the guide assembly.

14. The method of performing operations on elongate workpieces according to claim **13** wherein the guide assembly has a second opening and after relatively repositioning the spindle and guide assembly, the one of the first and second elongate workpieces passes through the second opening.

15. The method of performing operations on elongate workpieces according to claim **14** wherein the first and second openings each have a diameter and the diameter of the second opening is greater than the diameter of the first opening.

16. The method of performing operations on elongate workpieces according to claim **13** wherein the step of relatively repositioning comprises relatively repositioning the spindle and guide assembly along a plane orthogonal to the central axis.

17. The method of performing operations on elongate workpieces according to claim **16** wherein the step of relatively repositioning comprises rotating the guide assembly around an axis.

18. The method of performing operations on elongate workpieces according to claim **16** wherein the step of relatively repositioning comprises translating the guide assembly along a line.

19. The method of performing operations on elongate workpieces according to claim **13** wherein the step of performing an operation comprises performing an operation on an end of the first elongate workpiece that is passed through the guide assembly.

20. The method of performing operations on elongate workpieces according to claim **13** wherein the second elongate workpiece has a first diameter and the guide assembly has a second opening through which the second elongate workpiece passes at the location spaced from the first guide opening with a diameter substantially greater than the first diameter.

21. The method of performing operations on elongate workpieces according to claim **20** wherein the second elongate workpiece is unguided by the guide assembly with the second elongate workpiece passed through the second opening.

* * * * *

US006637519B2

(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,637,519 B2**
(45) **Date of Patent: Oct. 28, 2003**

(54) **SYSTEM AND METHOD FOR EXTINGUISHING A FIRE**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **U.S. Cl.** **169/46**; 169/56; 169/57; 169/59; 169/60; 169/5; 169/19; 169/20

(58) **Field of Search** 169/46, 56, 57, 169/59, 60, 5, 6, 8, 19, 20

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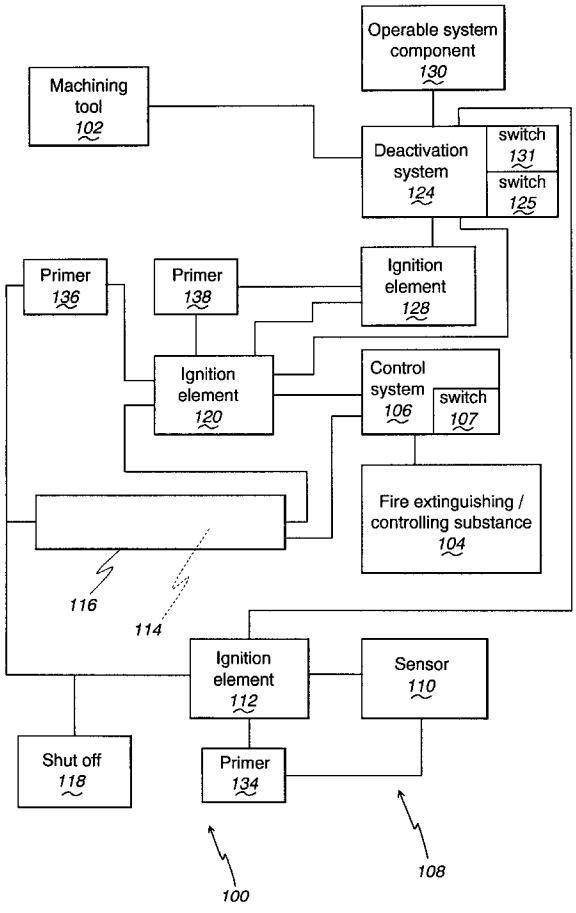
Primary Examiner—Robin O. Evans
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A system and method for extinguishing or controlling a fire. The system has a source of a substance which is usable to extinguish a fire in a prescribed area, a control system, and an activation system. The control system has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area. The activation system has a first ignition element which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion. The control system is changeable from the first state into the second state an incident of the first ignition element being ignited.

10 Claims, 2 Drawing Sheets



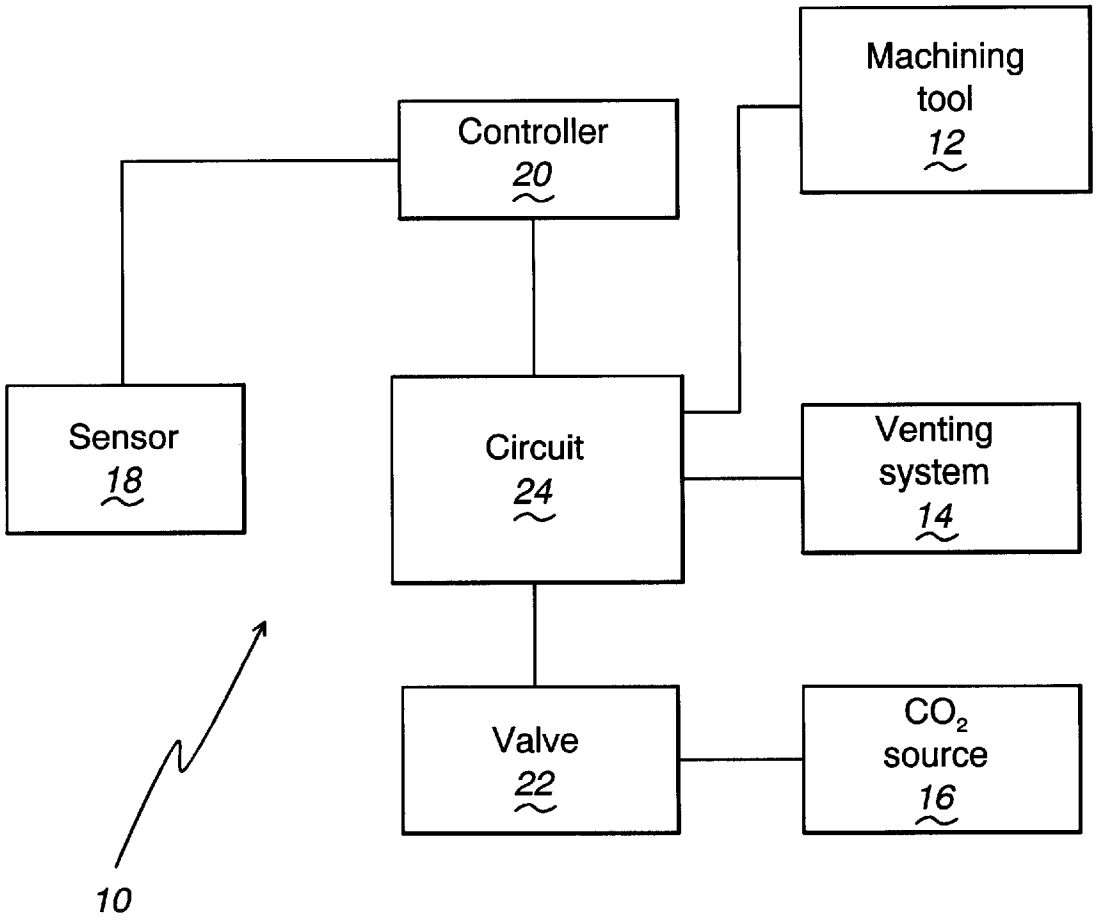


Fig. 1 (prior art)

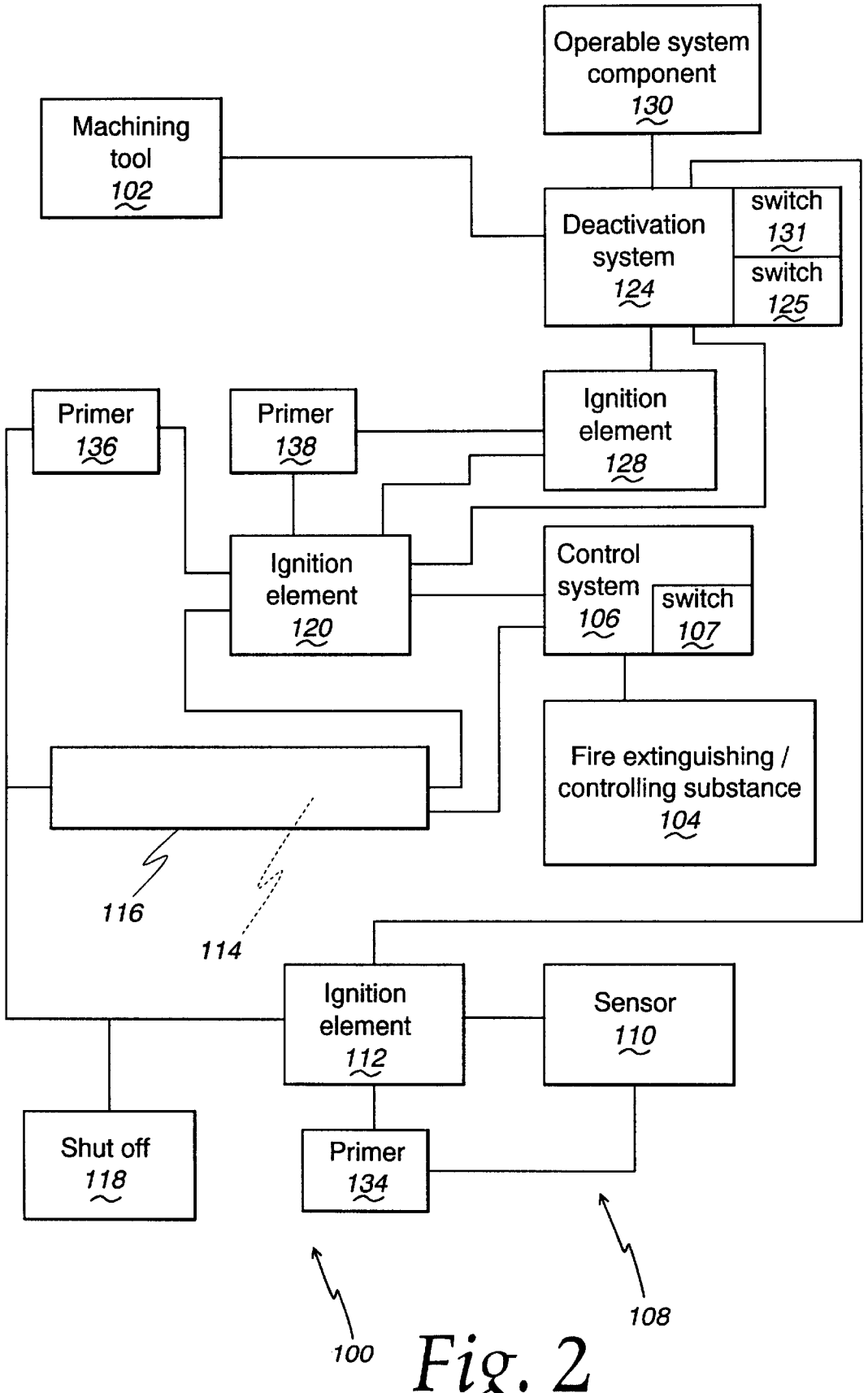

Operable system component 130
Machining tool 102
Deactivation system 124
switch 131
switch 125
Primer 136
Primer 138
Ignition element 128
Ignition element 120
Control system 106
switch 107
Fire extinguishing / controlling substance 104
116
114
Ignition element 112
Sensor 110
Shut off 118
Primer 134
100
108

Fig. 2

SYSTEM AND METHOD FOR EXTINGUISHING A FIRE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a system and method for automatically extinguishing or controlling a fire which is burning in a prescribed area.

2. Background Art

In many environments, systems have been designed for automatically extinguishing or controlling a fire that may be inadvertently started. One such system will be described below with respect to an exemplary environment.

As shown in FIG. **1**, a system for extinguishing a fire is shown at **10** in association with a machine tool **12**, which may have any of a multitude of different constructions and capabilities. The machine tool **12** operates in a prescribed area in which a fire may be inadvertently started during normal machining operations. Typically, rooms in which the machine tool **12** is operated utilize venting systems **14** which direct oil, water particles, and other matter entrained in the air within a machining space, to an appropriate location for collection or discharge. The venting system **14**, while enhancing the environment around the machine tool **12** for human occupation, also vents the region around the machine tool **12** so as to contribute to the spread of any fire that may have started.

The function of the system **10** is threefold. First, the system **10** causes an extinguishing substance, in this case shown as CO_2 contained at a source **16**, to be directed at the fire. Secondly, the system **10** closes the venting system **14** so as not to facilitate fire propagation. Finally, the system **10** causes the machine tool **12** to be shut down.

To effect the above three functions, one conventional system utilizes a sensor **18** to detect the presence of smoke or fire. The sensor **18** may take any of myriad different forms known to those skilled in the art. Upon detecting either smoke or fire, the sensor **18** sends a signal to a central controller **20**, which coordinates operation of the machine tool **12**, the venting system **14**, and a valve **22**, which selectively releases the CO_2 from the source **16**. The controller **20** effects shutdown of the machine tool **12** and venting system **14**, and operates the valve **22**, through an electrical circuit **24**.

While systems, such as that shown at **10** in FIG. **1**, have been generally effective, systems of this type that rely on electrical circuitry may be prone to malfunction by reason of either their complexity or their sensitivity to heat or contamination generated during a fire. The machine tool industry, as well as other industries, is constantly seeking new and better ways to control inadvertently started fires in this type of environment.

SUMMARY OF THE INVENTION

In one form, the invention is directed to a system for extinguishing a fire. The system has a source of a substance which is usable to extinguish or control a fire in a prescribed area, a control system, and an activation system. The control system has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area. The activation system has a first ignition element

which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion. The control system is changeable from the first state into the second state an incident of the ignition element being ignited.

In one form, there is no electrical circuitry which is responsible for changing the control system from the first state into the second state.

In one form, the control system consists of a pressure responsive switch which changes from a normal state into an activated state as an incident of the first ignition element being ignited. The control system is in the first state with the pressure responsive switch in the normal state and in the second state with the pressure responsive switch in the activated state.

In one form, there is a conduit which has a passageway in which pressure is generated in response to ignition of the first ignition element and which causes the pressure responsive switch to change from the normal state into the activated state.

A shutoff may be provided for selectively blocking the passageway between the first ignition element and pressure responsive switch to disable the activation system.

The system may further include a second ignition element which is ignited as an incident of the first ignition element being ignited.

The ignition of the second ignition element causes the control system to change from the first state into the second state.

In one form, the substance used to extinguish or control the fire is CO_2.

The system may include an operable system component in addition to the control system and having an operating state and a disabled state, a deactivation system, and a second ignition element which is ignited in response to ignition of the first ignition element to cause the deactivation system to change from a normal state into a deactivation state. The operable system component changes from the operating state into the disabled state as an incident of the deactivation system changing form the normal state into the deactivation state. This same function may be effected without the requirement for the second ignition element.

In one form, the operable system component is one of a machine tool and a venting system for atmospheric air in the vicinity of the prescribed area.

The venting system may have an associated damper which is changeable between open and closed states. The damper is in the open state with the venting system in the operating state and in the closed state with the venting system in the disabled state.

The ignition element may include an explosive component.

The invention is also directed to a method of extinguishing a fire in a prescribed area. The method includes the steps of: situating a first ignition element in the vicinity of the prescribed area; in response to exposure of the first ignition element to at least of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion, causing the first ignition element to ignite; and in response to ignition of the first ignition element causing a control system to release a substance from a source of the substance to the prescribed area to extinguish or control a fire in the prescribed area.

The method may further include the step of changing an operable system component in addition to the control system

from an operating state into a disabled state in response to ignition of the first ignition element.

The operable system component may be one of (a) a machine tool for performing a processing operation on a workpiece and (b) a venting system for atmospheric air in the vicinity of the prescribed area.

The method may further include the step of causing the first ignition element to ignite a second ignition element. The ignition of the second ignition element causes the control system to release the substance to the prescribed area to extinguish or control a fire in the prescribed area.

The first ignition element may ignite a second ignition element so that the second ignition element causes the operable system component to change from the operating state into the disabled state.

The first ignition element may include an explosive component.

The substance used to extinguish or control the fire may be CO_2.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of a prior art system for extinguishing fire in a machine tool environment; and

FIG. **2** is a schematic representation of a system for extinguishing fire in a machine tool environment according to the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

One system for extinguishing a fire, according to the present invention, is shown at **100** in FIG. **2**. The system **100** is shown in a machining environment with an operable component in the form of a machine tool **102**. It should be understood that the inventive system **100** can be used in virtually any environment wherein automatic fire extinguishing or controlling capability is desired, with the machine tool environment used herein only for purposes of illustration.

The system **100** is designed to cause the discharge of a fire extinguishing/controlling substance from a source **104** in a prescribed area around the machine tool **102**. The fire extinguishing substance at the source **104** may be any substance commonly used for this purpose. CO_2 is commonly used in this environment.

The substance in the source **104** is selectively releasable through operation of a control system **106**. The control system **106** has a first state in which the fire extinguishing/controlling substance from the source **104** is prevented from being released to the prescribed area and a second state wherein the substance from the source **104** is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area. In this embodiment, the control system incorporates a pressure responsive switch **107** which has a normal state with the control system in the first state and an activated state with the control system in the second state.

The system **100** has an activation system **108** which is responsible for changing the switch **107** from the normal state into the activated state, and thereby the control system **106** from the first state into the second state. In its simplest form, the activation system **108** consists of a sensor **110** and an ignition element **112**. The sensor **110** may be part of the ignition element **112** and is responsible for causing the ignition element **112** to ignite upon exposure of the sensor **10** to at least one of a flame, heat above a predetermined temperature, and a product of combustion. Alternatively, the sensor **110** may be a separate element designed to react in response to exposure to a flame, heat, or a product of combustion to produce an ignition stimulus to the ignition element **112**. The ignition element **112** may be made in replaceable cartridge form so that the activation system **108** may be deployed and thereafter set up again for reuse.

The sensor **110**, which functions as described above, may be made in any of a multitude of different forms. Those skilled in the art are familiar with sensors **110** capable of detecting fire, or imminent fire indicators, to initiate the extinguishing process.

The ignition element **112**, in response to being ignited, produces a stimulus to change the switch **107** from the normal state into the activated state and thereby the control system **106** from the first state into the second state. In one form, the ignition element **112** includes an explosive component, such as gunpowder, which, upon being ignited, produces a pressure rise or shock. In the embodiment shown, pressure from the ignition of the ignition element **112** is generated in a passageway **114** of a conduit **116** so that the increasing pressure is eventually caused, through the conduit **116**, to be impinged upon the control system **106** to effect change thereof from the first state into the second state.

Many different types of pressure responsive switches can be used in the control system **106** to allow operation as described above. For example, the switch **107** may be a simple diaphragm, acting as a valve, that is repositioned under the pressure change resulting from the explosion to allow the change of state of the control system **106**. As another example, the control system **106** may include an element which breaks or reconfigures in response to the increased pressure from the ignition/explosion of the ignition element **112**, as an incident of which the control system **106** changes from the first state into the second state. As a further alternative, a spring-loaded repositionable element can be used. A movable, biased shutter may reposition in response to the pressure surge to change the state of the control system **106**. Consequently, with the system **100** as described above, there is no need for any electrical circuitry to change the control system **106** from the first state into the second state therefor. The invention can be used as an alternative to an electrically operated control system or as a backup to such a system

The activation system **108** can be selectively disabled by a shutoff **118**, which may block the passageway **114**, or communication of pressure from the ignition explosion to the passageway **114**, to prevent a pressure build-up at the control system **106** sufficient to change the state thereof.

The ignition element **112** is described to be ignitible to directly change the state of the control system **106**. As an alternative to this arrangement, or in conjunction therewith, a second ignition element **120** may be interposed between the ignition element **112** and the control system **106**. The ignition element **120** may have the same general construction as the ignition element **112**. The ignition element **120** is ignited by the ignition/explosion of the ignition element **112**. This may effect a more positive operation of the control system **106** and provides a redundant pressure application to the control system **106** for reliable operation thereof.

In addition to discharging the fire extinguishing substance at the prescribed area in the vicinity of the machine tool **102**, the system **100** is designed to additionally shut the machine tool **102** down from an operating state into a disabled state after a fire or fire precursor is detected at the sensor **110**. This is accomplished through a deactivation system at **124**. The deactivation system **124** may include a pressure responsive

switch **125** that is changeable from a normal state into a deactivation state in response to the ignition of the ignition element **112**. The ignition element **112** may directly and by itself operate the deactivation system **124**. Alternatively, the ignition element **112** may cause ignition of the ignition element **120**, which in turn ignites an ignition element **128** to effect the change of state of the deactivation system **124**. The ignition element **128** may have the same construction as the ignition element **112**. Alternatively, the ignition element **112** may directly produce pressure on the pressure sensitive switch **125** on the deactivation system **124** in conjunction with pressure from the ignition element **128** produced through the chain reaction from ignition of the ignition element **112** and in turn the ignition element **120** and ignition element **128**.

The deactivation system **124** may be responsible for disabling another operable system component **130**, such as the venting system **14**, previously described. As noted, through the venting system **14**, entrained liquid or solid particles, generated during the machining operations, may be conveyed through a pressure differential to an accumulation site or exhausted, as to the outside of a building. This venting system **14** also creates an environment more conducive to burning and it is thus desirable that the venting system **14** be changed from an open operating state into a closed disabled state. The deactivation system **124** may have a separate pressure sensitive switch **131** which responds to the ignition of the ignition element **112** alone, or ignition of the ignition element **112** and/or ignition element **128**, to change the state of the operable system component **130**.

Similarly, the deactivation system **124** can be designed to deactivate an operable system component **130** without any electrical circuitry between the sensor **110** and the deactivation system **124**. The potential redundant pressure activation from the ignition elements **112,120,128** improves reliability even further.

Each ignition element **112,120,128** may be ignited through an optional intermediate primer **134,136,138**, consecutively. The primers **134,136,138** may likewise be made in replaceable cartridge form.

In operation, once the sensor **110** detects either fire or a fire precursor, the ignition element **112** is caused to be ignited which causes, directly or indirectly, the change in the control system **106** from its first state into its second state. This allows the discharge of the CO_2, or other fire extinguishing substance **104**, to the prescribed area around the machine tool **102**. At the same time, the ignition of the ignition element **112** directly and/or indirectly causes the deactivation system **124** to change from the normal state into the deactivation state therefor which disables both the machine tool **102** and the other operable system component **130**, which may be the venting system, such as a venting system **14** in FIG. **1**. The pressure transmission at each critical point in the system **10** may be effected using conduits defining passageways, such as the conduit **116** defining the passageway **114**, or by any other means known to those skilled in this art.

While the invention has been described with particular reference to the drawings, it should be understood that various modifications could be made without departing from the spirit and scope of the present invention.

What is claimed is:

1. A system for extinguishing a fire, the system comprising:

a source of a substance which is usable to extinguish a fire in a prescribed area;

a control system which has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area; and

an activation system comprising a first ignition element which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion,

the control system changeable from the first state into the second state as an incident of the ignition element being ignited,

wherein there is a conduit which has a passageway in which pressure is generated by ignition of the first ignition element and which causes the pressure responsive switch to change from the normal state into the activated state; and

a shutoff for selectively blocking the passageway between the first ignition element and pressure responsive switch to disable the activation system.

2. A system for extinguishing a fire, the system comprising:

a source of a substance which is usable to extinguish a fire in a prescribed area;

a control system which has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area;

an activation system comprising a first ignition element which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion,

the control system changeable from the first state into the second state as an incident of the ignition element being ignited; and

a second ignition element which is ignited as an incident of the first ignition element being ignited, the ignition of the second ignition element causing the control system to change from the first state into the second state.

3. A system for extinguishing a fire, the system comprising:

a source of a substance which is usable to extinguish a fire in a prescribed area;

a control system which has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area;

an activation system comprising a first ignition element which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion,

the control system changeable from the first state into the second state as an incident of the ignition element being ignited; and

an operable system component in addition to the control system and having an operating state and a disabled state, a deactivation system, and a second ignition element which is ignited in response to ignition of the first ignition element to cause the deactivation system

to change from a normal state into a deactivation state, the operable system component changing from the operating state into the disabled state as n incident of the deactivation system changing from the normal state into the deactivation state.

4. A system for extinguishing afire, the system comprising:

a source of a substance which is usable to extinguish a fire in a prescribed area;

a control system which has (a) a first state in which the substance from the source is prevented from being released to the prescribed area and (b) a second state wherein the substance from the source is permitted to be released to the prescribed area to extinguish or control a fire at or adjacent to the prescribed area;

an activation system comprising a first ignition element which ignites in response to exposure to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion,

the control system changeable from the first state into the second state as an incident of the ignition element being ignited;

an operable system component in addition to the control system and having an operating state and a disabled state, and a deactivation system, ignition of the first ignition element causing the deactivation system to change from a normal state into a deactivation state, the operable system component changing from the operating state into the disabled state as an incident of the deactivation system changing from the normal state into the deactivation state.

5. The system for extinguishing a fire according to claim **4** wherein the operable system component comprises a machine tool for performing a processing operation on a workpiece.

6. The system for extinguishing a fire according to claim **4** wherein the operable system component comprises a venting system for atmospheric air in the vicinity of the prescribed area.

7. The system for extinguishing a fire according to claim **6** wherein the venting system has an associated damper which is changeable between open and closed states, the damper being in the open state with the venting system in the operating state and in the closed stated with the venting system in the disabled state.

8. A method of extinguishing a fire in a prescribed area, the method comprising the steps of:

situating a first ignition element in the vicinity of the prescribed area;

in response to exposure of the first ignition element to at least one of (a) a flame, (b) heat above a predetermined temperature, and (c) a product of combustion, causing the first ignition element to ignite;

in response to ignition of the first ignition element causing a control system to release a substance from a source of the substance to the prescribed area to extinguish or control a fire in the prescribed area; and

changing an operable system component in addition to the control system from an operating state into a disabled state in response to ignition of the first ignition element.

9. The method of extinguishing a fire according to claim **8** wherein the operable system component comprises one of (a) a machine tool for performing a processing operation on a workpiece and (b) a venting system for atmospheric air in the vicinity of the prescribed area.

10. The method of extinguishing a fire according to claim **8** further comprising the step of causing the first ignition element to ignite a second ignition element, the ignition of the second ignition element causing the operable system component to change from the operating state into the disabled state.

* * * * *

US006675451B1

(12) **United States Patent**
Miyano

(10) **Patent No.: US 6,675,451 B1**
(45) **Date of Patent: Jan. 13, 2004**

(54) **MACHINE TOOL AND METHOD OF USING THE MACHINE TOOL**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **U.S. Cl.** ..... **29/27 C**; 29/27 R; 82/1.11; 82/124; 82/127; 82/129
(58) **Field of Search** ..... 29/27 C, 27 R; 82/1.11, 129, 127, 124

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Primary Examiner—A. L. Wellington
Assistant Examiner—Doana Ross
(74) *Attorney, Agent, or Firm*—Wood, Phillips, Katz, Clark & Mortimer

(57) **ABSTRACT**

A method of processing a workpiece including the steps of: placing a first preform element in a first operative position on a first holder so that a first portion of the first preform element is exposed; performing a processing operation on the first portion of the first preform element with the first preform element in the first operative position; transferring the first preform element into a second operative position on a second holder; with the first preform element in the second operative position exposing a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position; and with the first preform element in the second operative position and the second portion of the first preform exposed, performing a processing operation on the second portion of the first preform element.

18 Claims, 12 Drawing Sheets

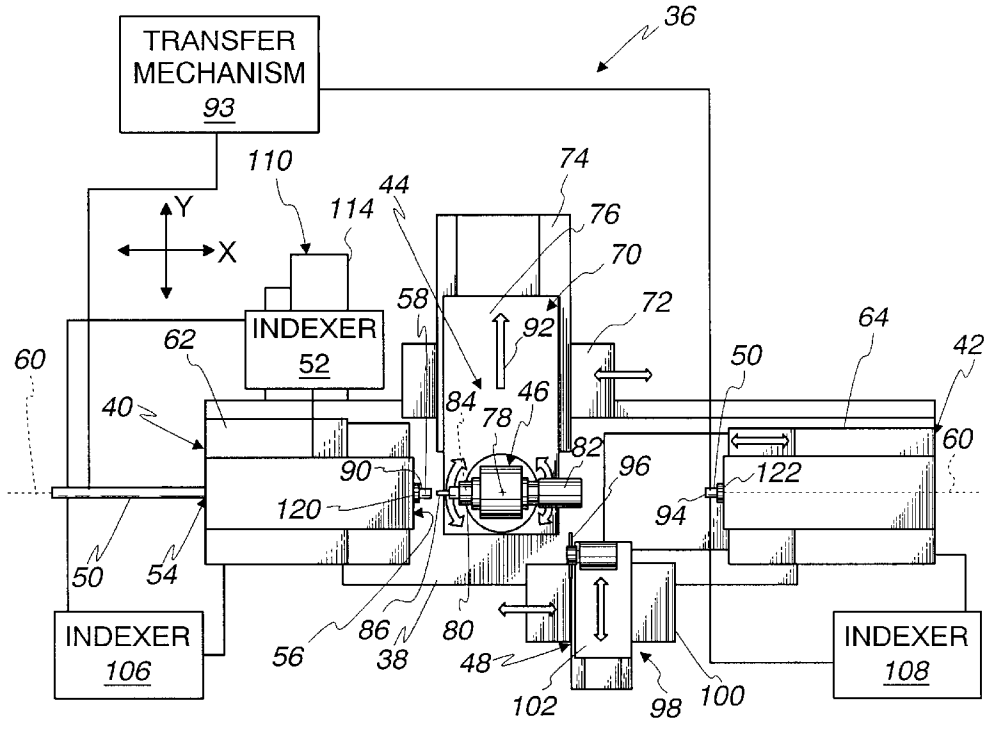

Fig. 1 - Prior Art

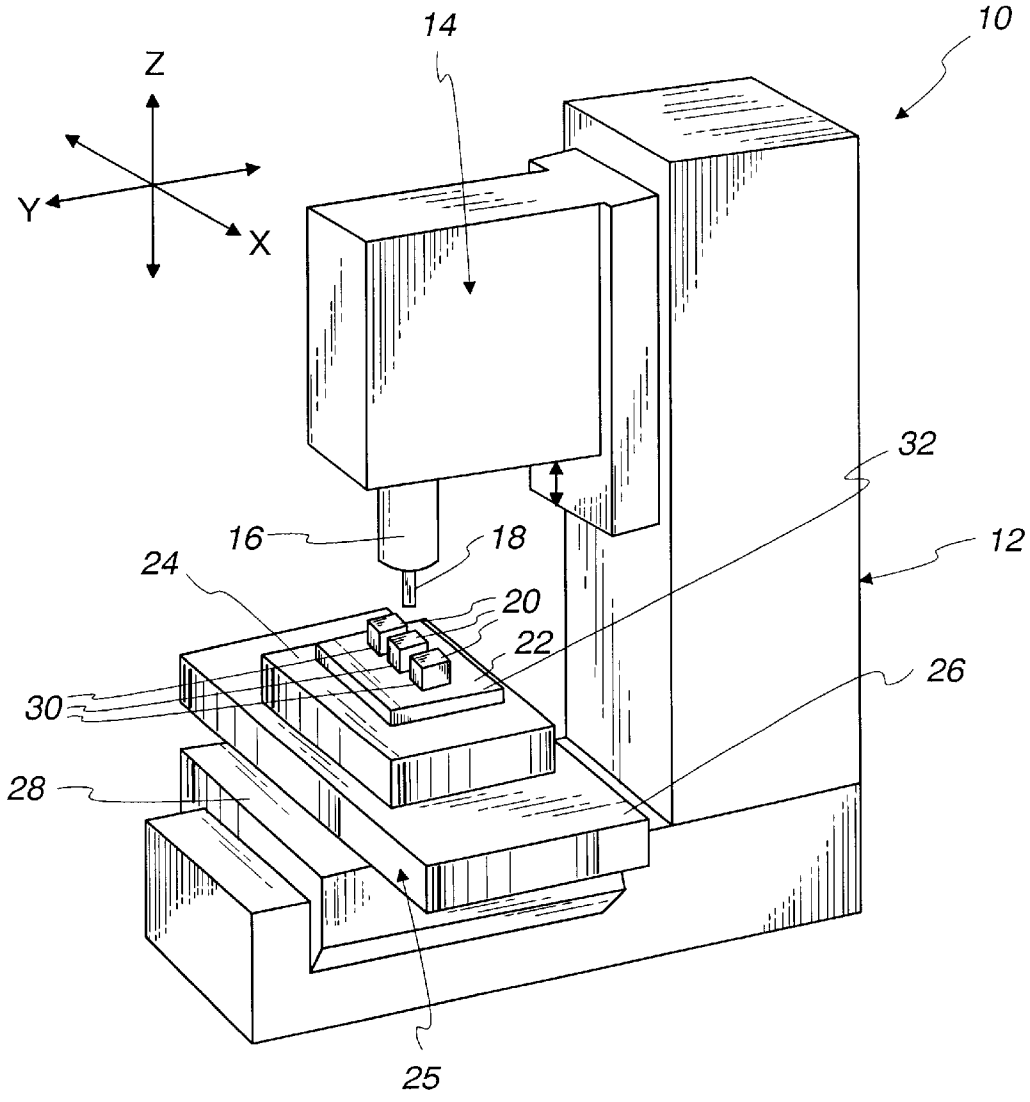

Fig. 2

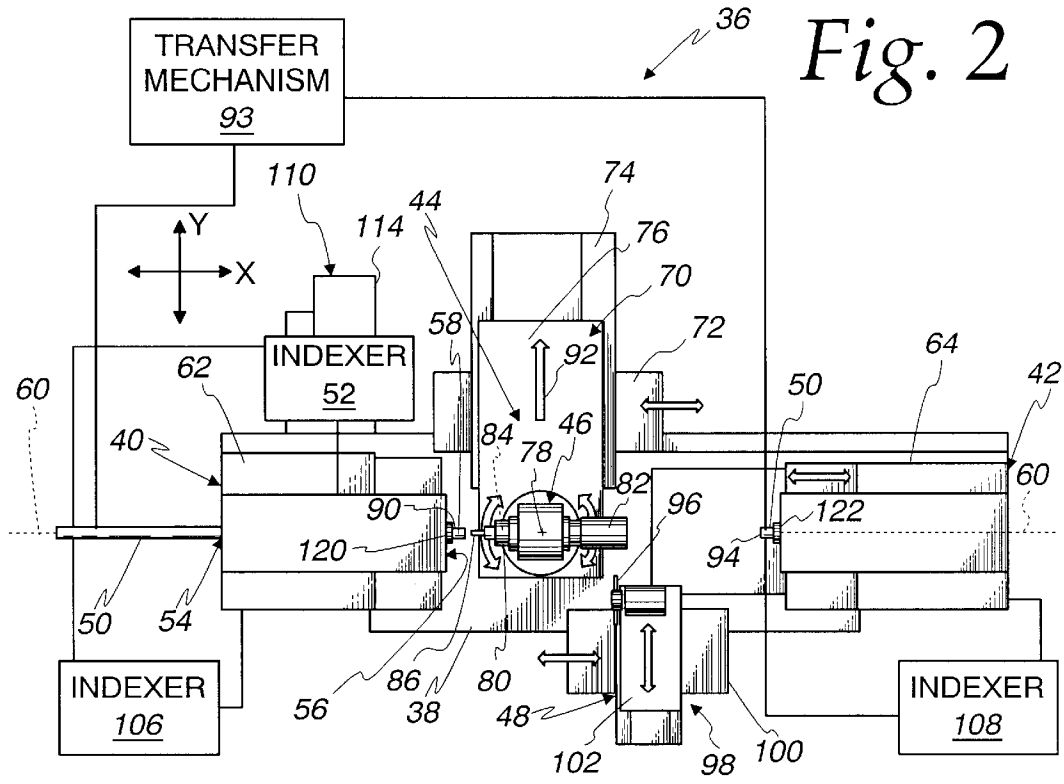
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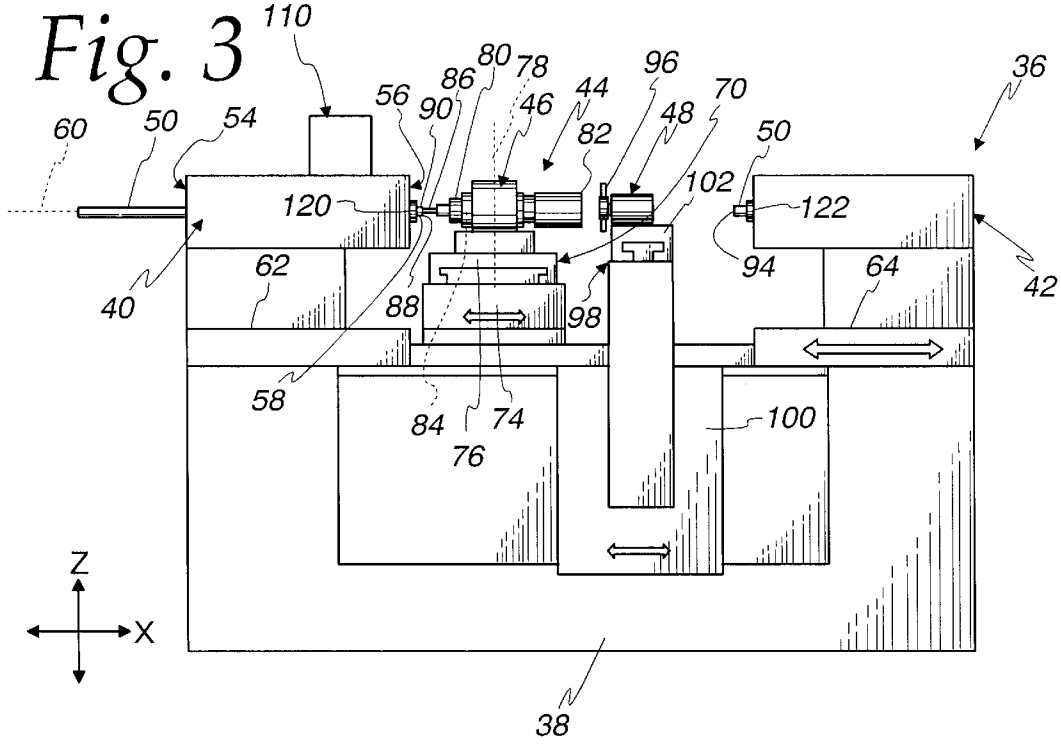
Fig. 3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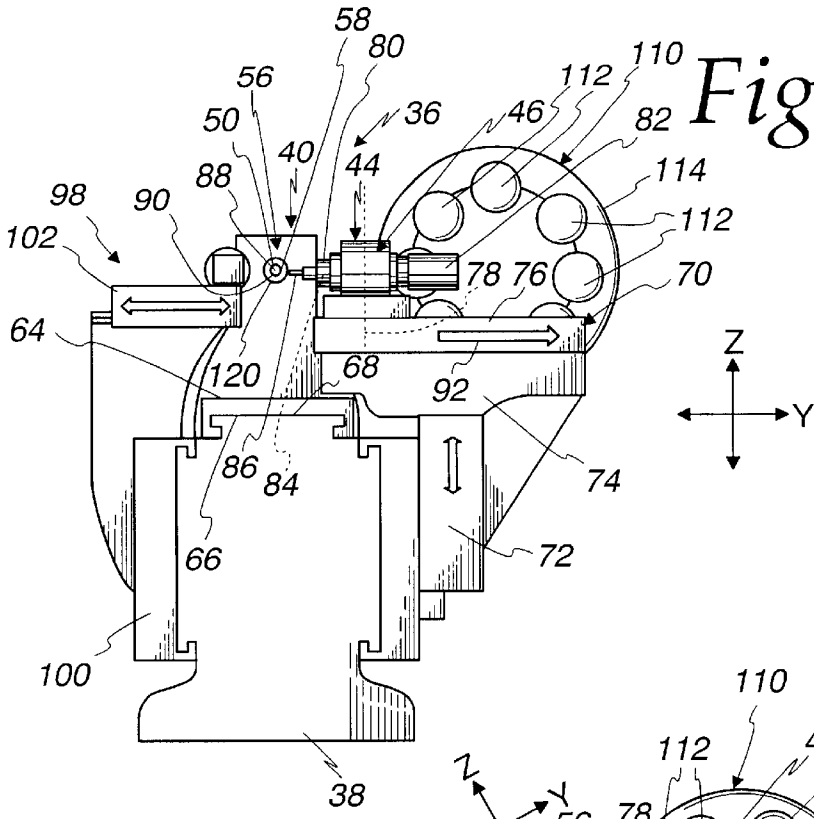
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Fig. 4

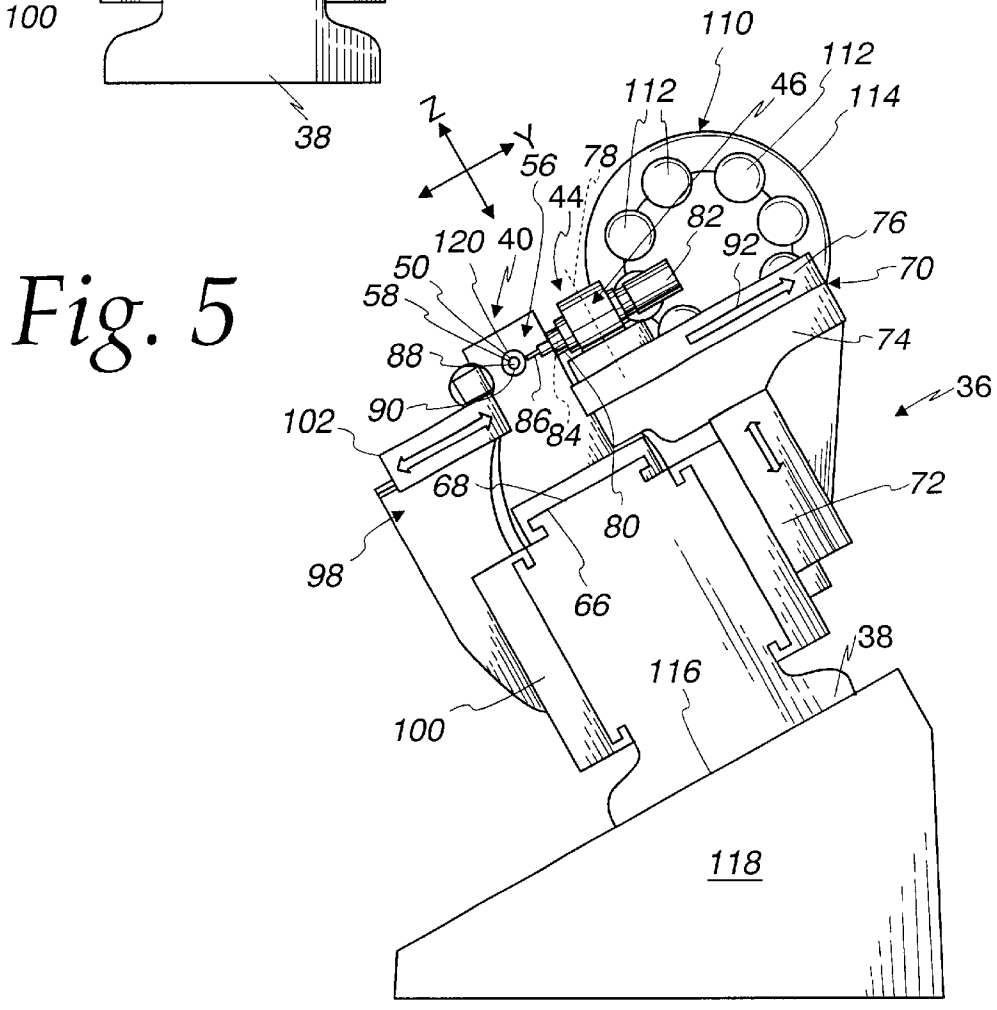
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Fig. 5

Fig. 6

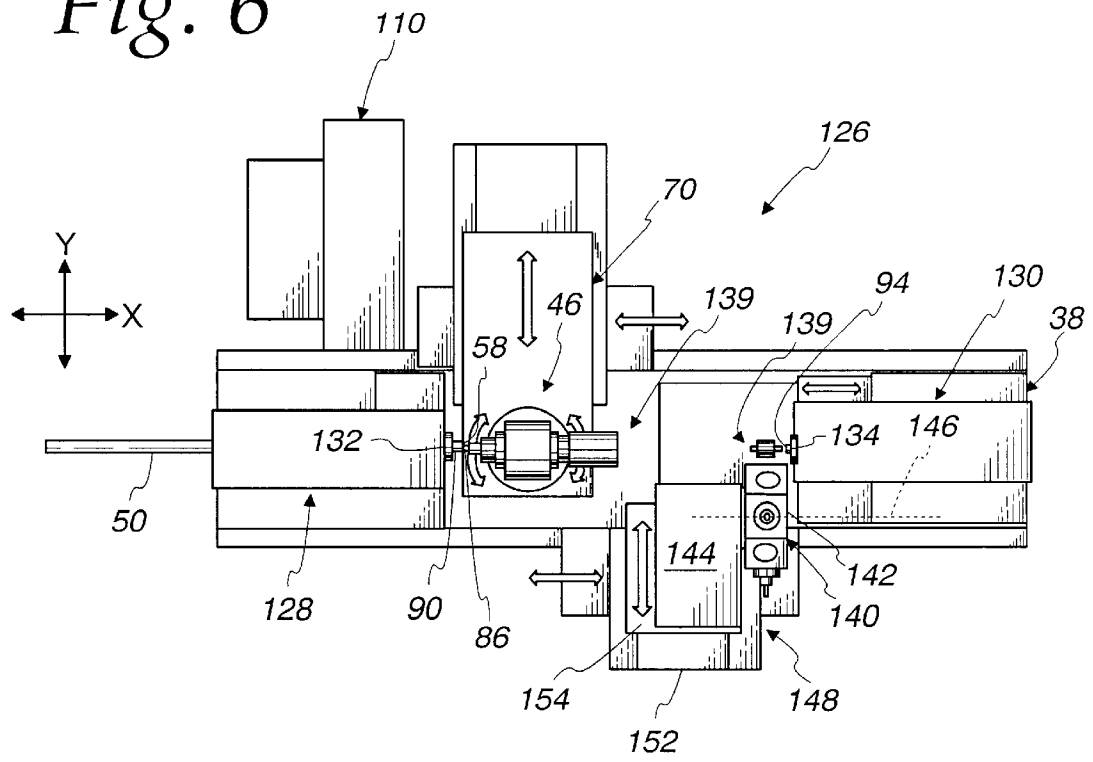
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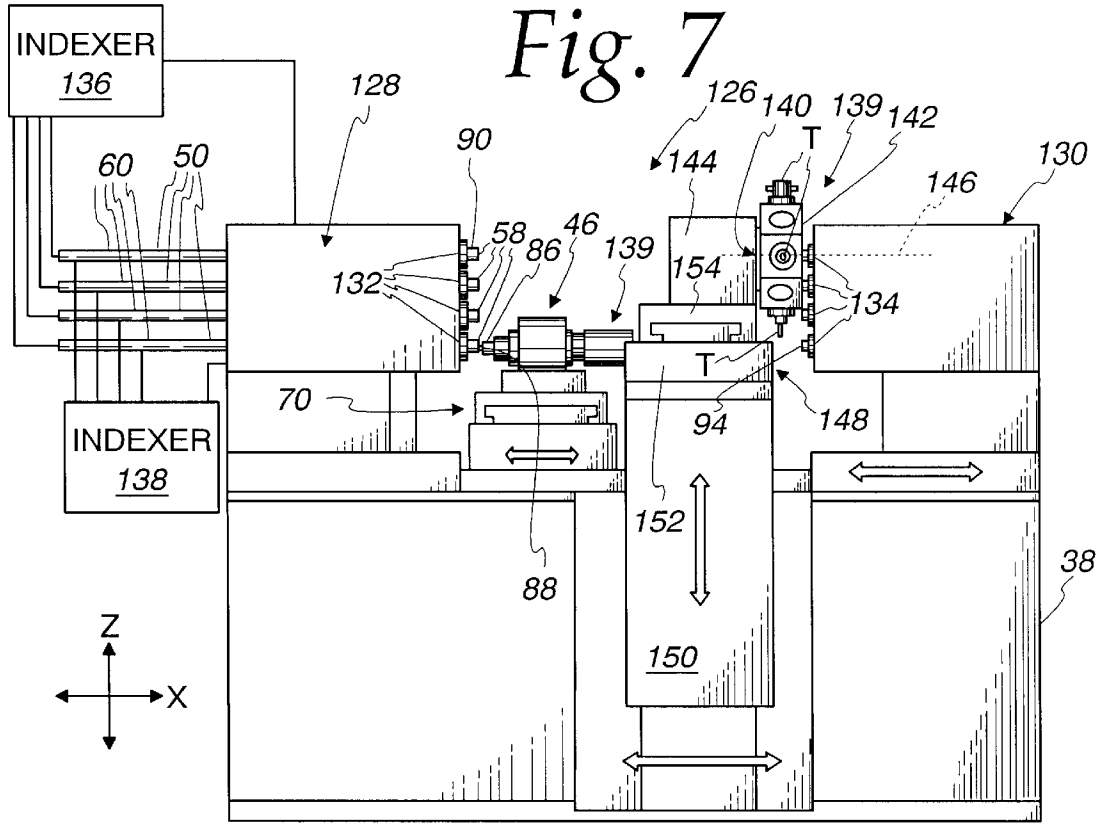
Fig. 7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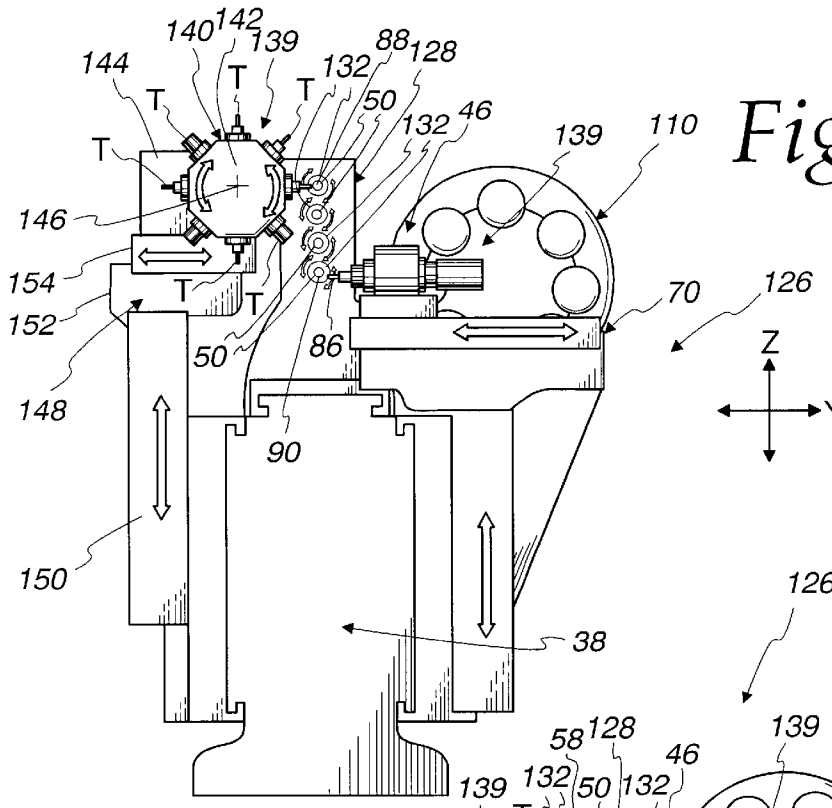
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Fig. 8

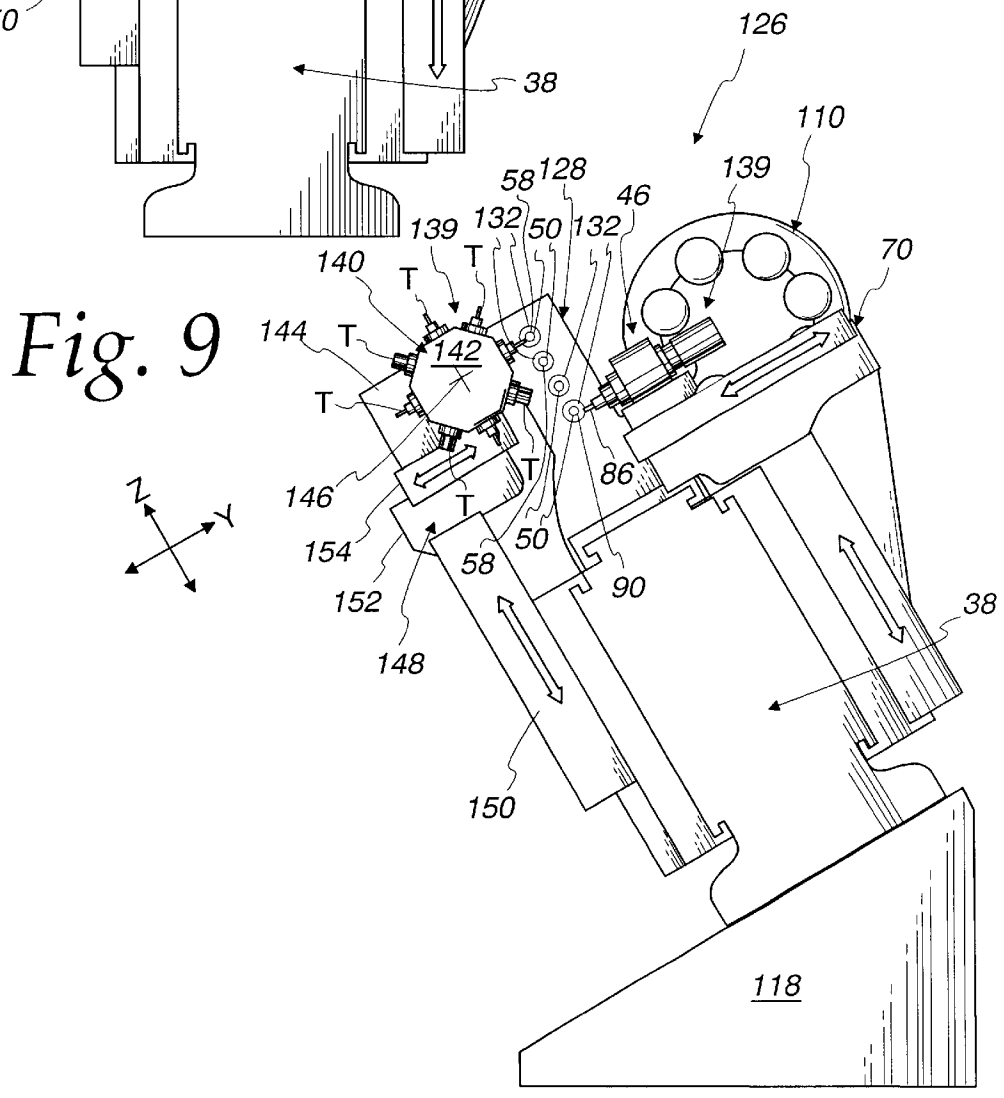
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Fig. 9

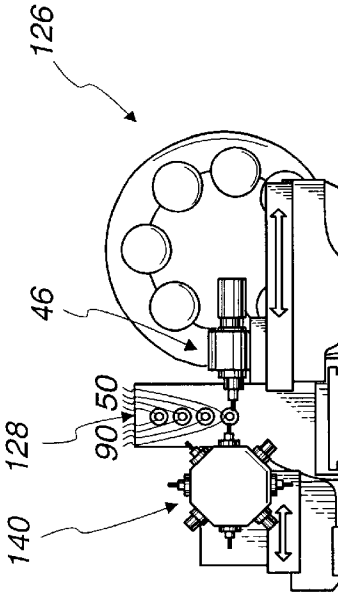


Fig. 10

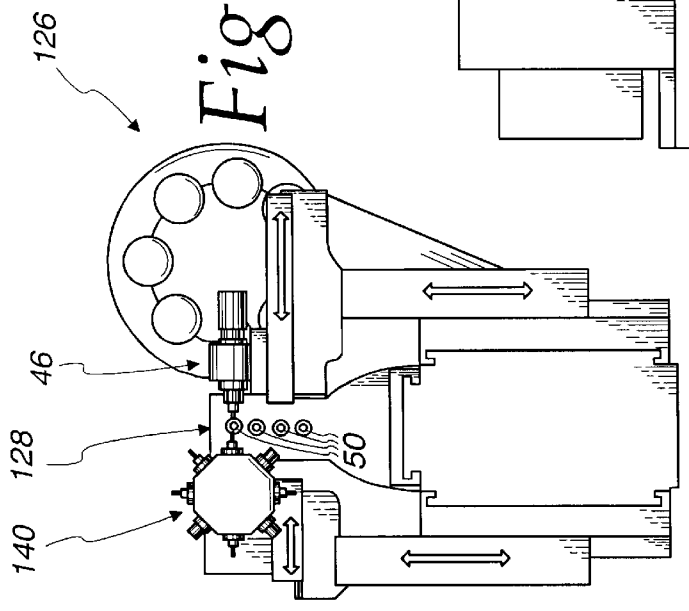


Fig. 11

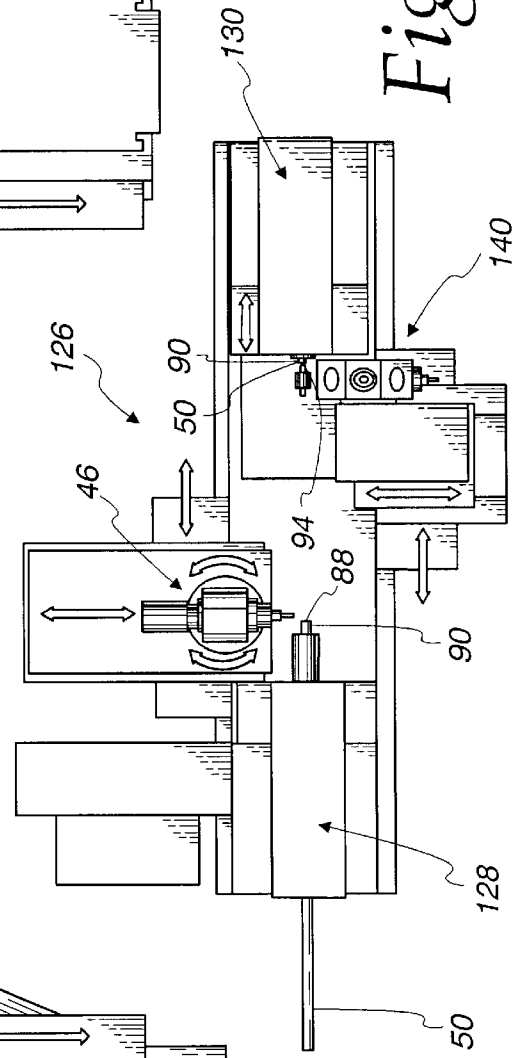


Fig. 12

Fig. 14

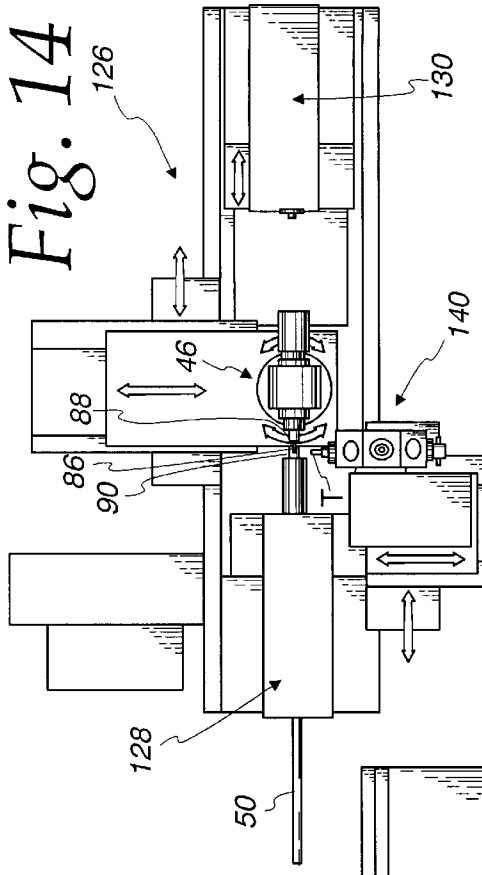


Fig. 15

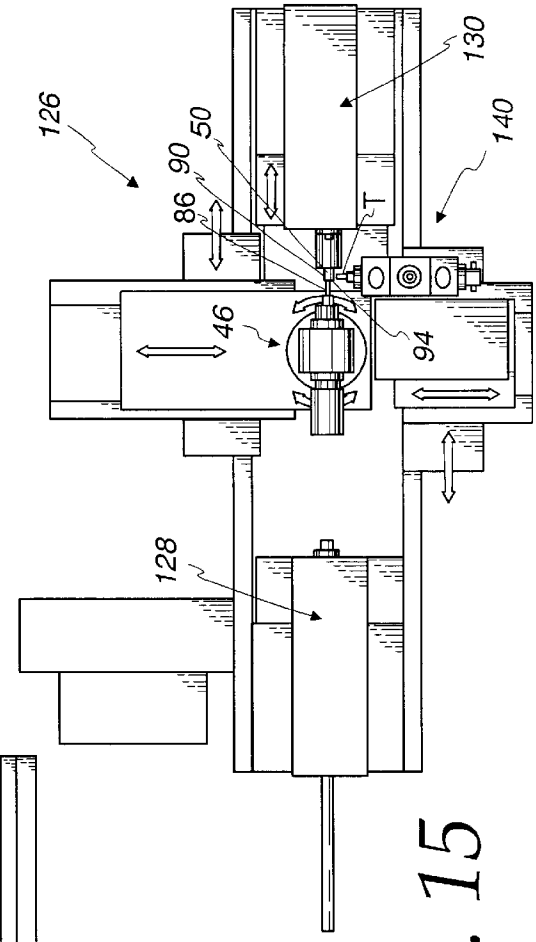


Fig. 13

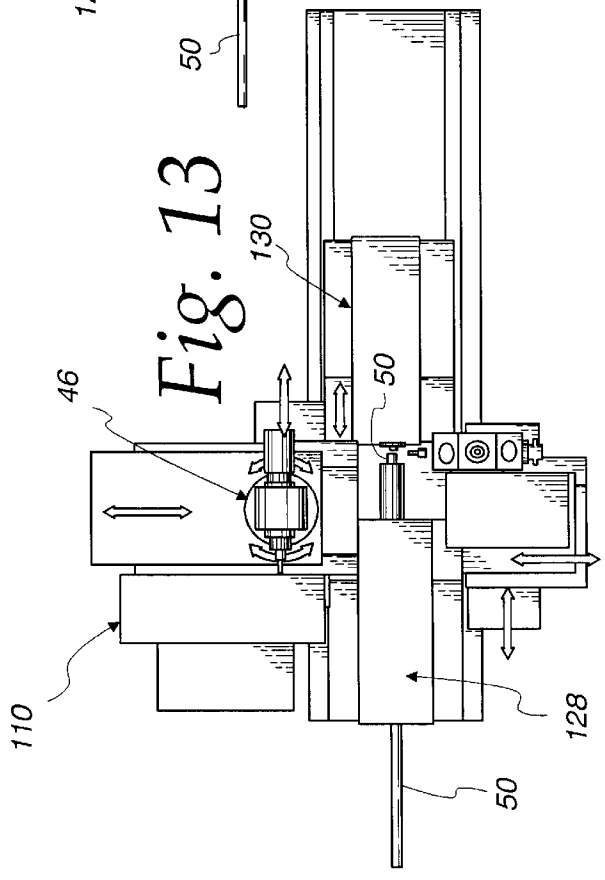


Fig. 16

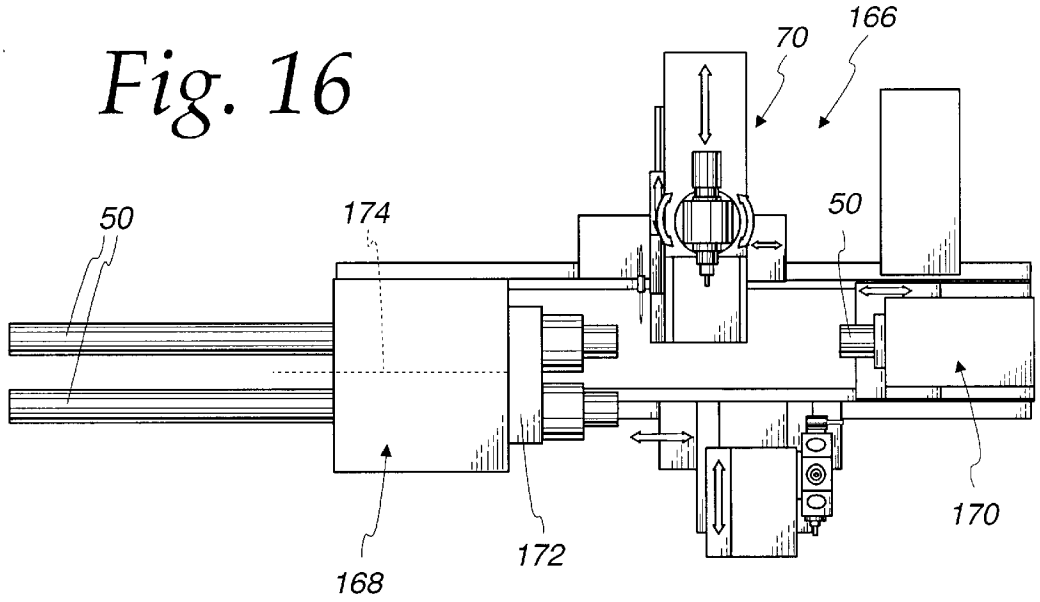


Fig. 17

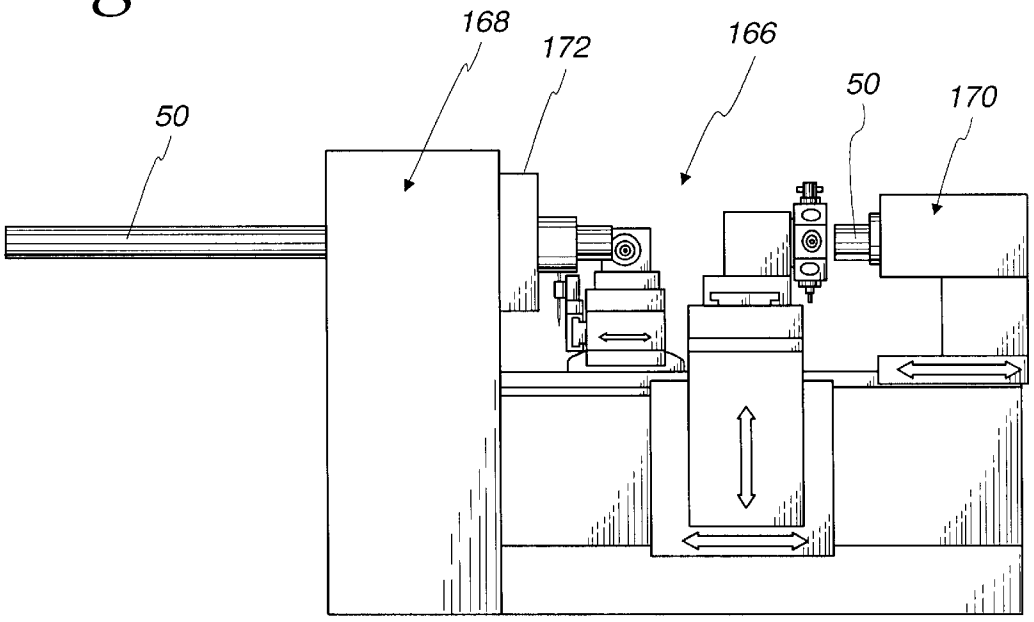
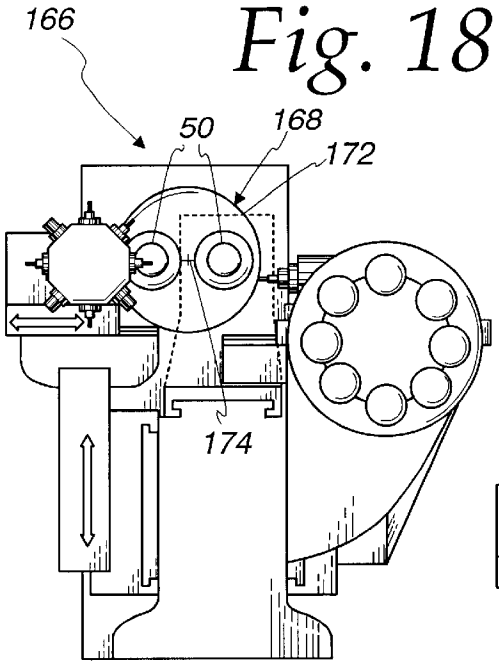


Fig. 18



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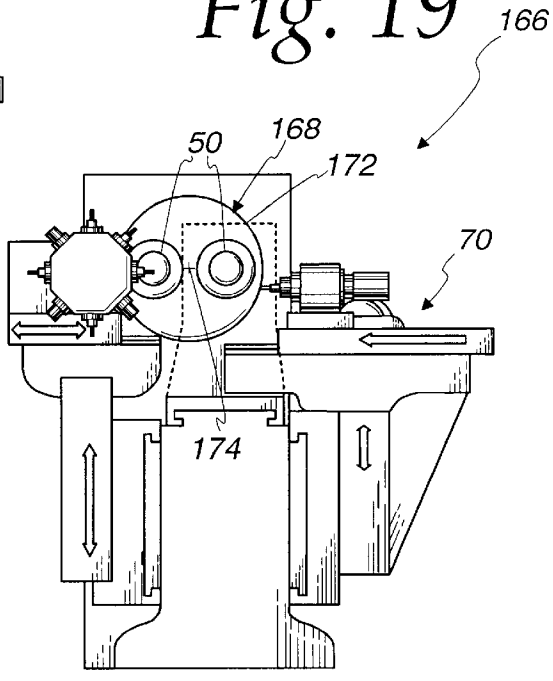


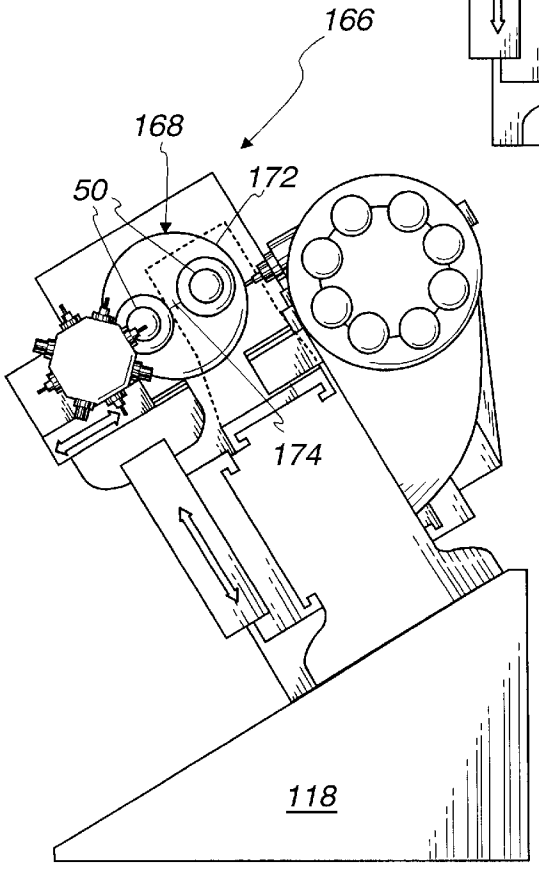
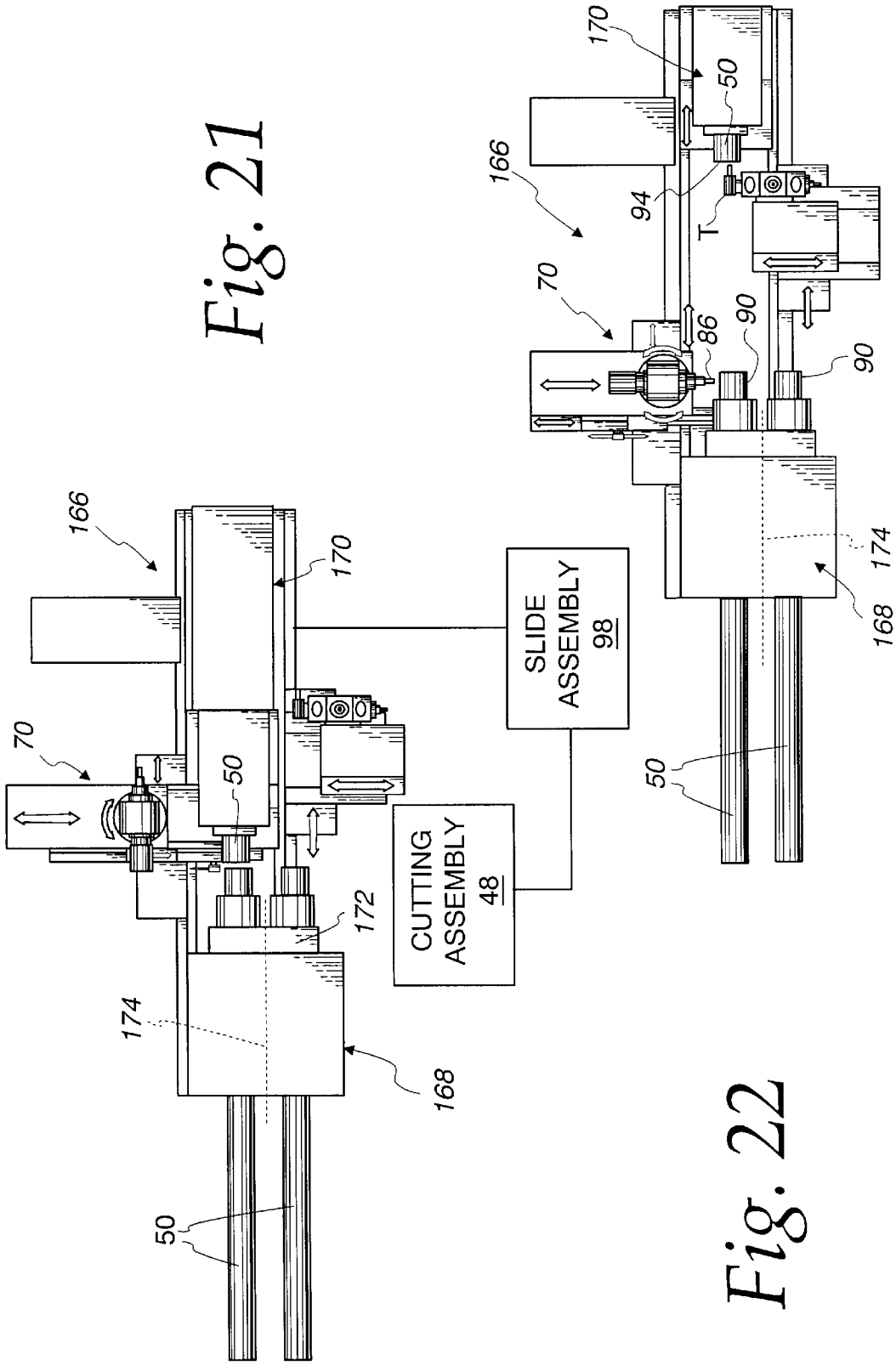


Fig. 20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SLIDE ASSEMBLY 98
CUTTING ASSEMBLY 48
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Fig. 21

Fig. 22

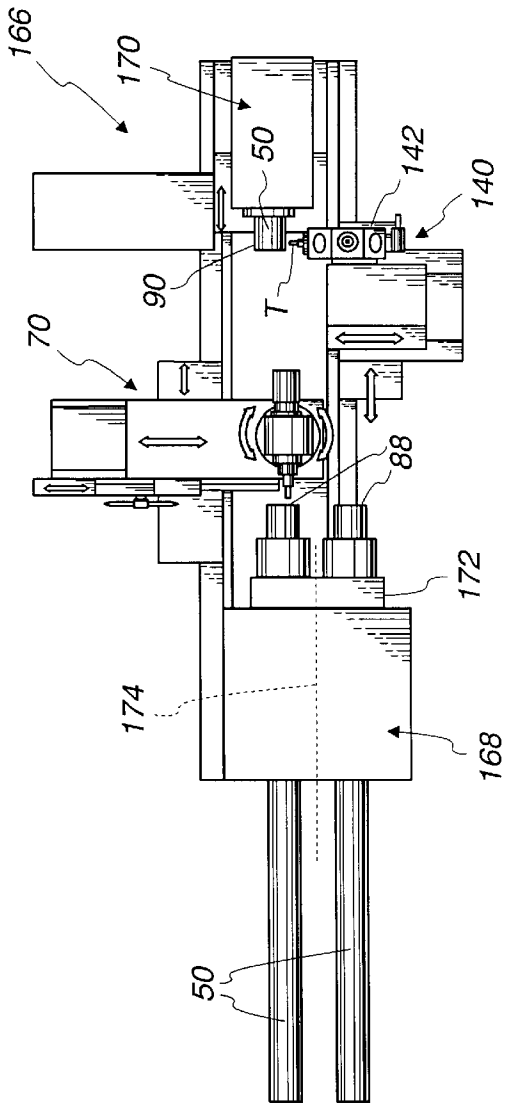
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Fig. 23

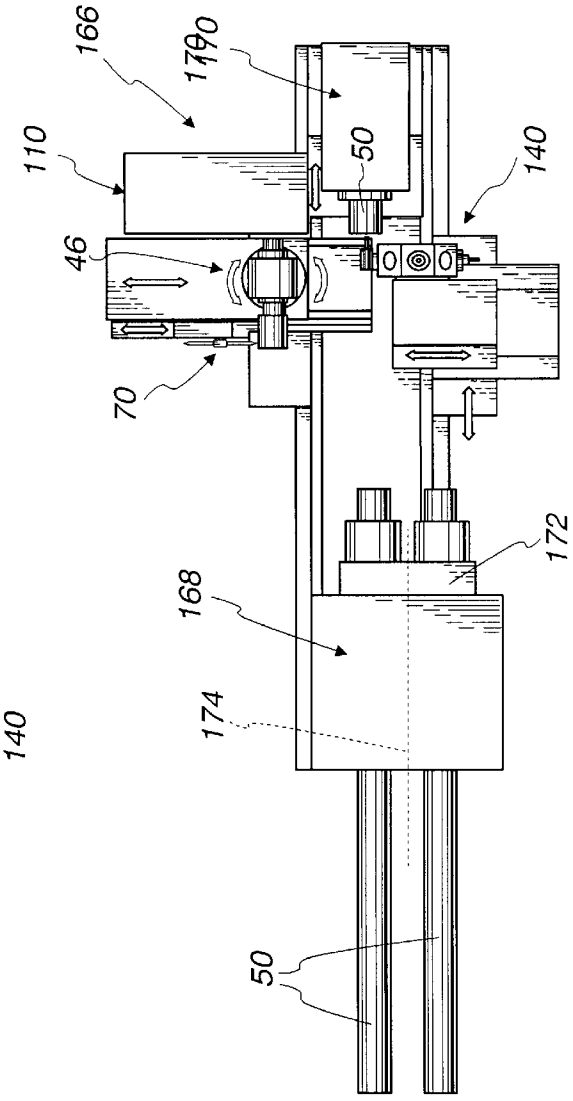
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Fig. 24

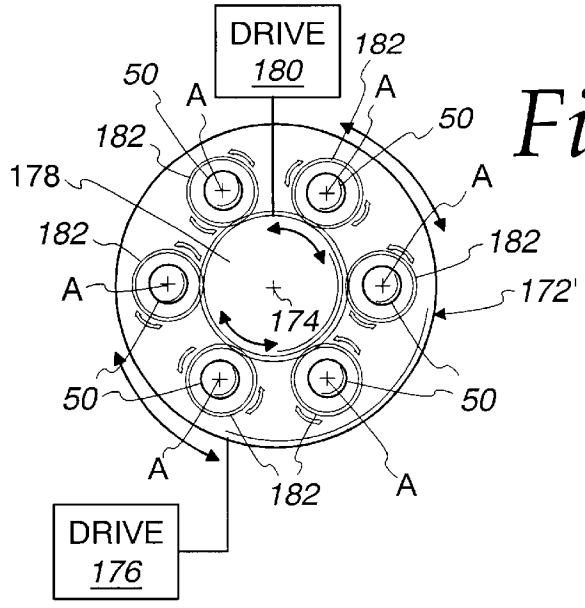

Fig. 25

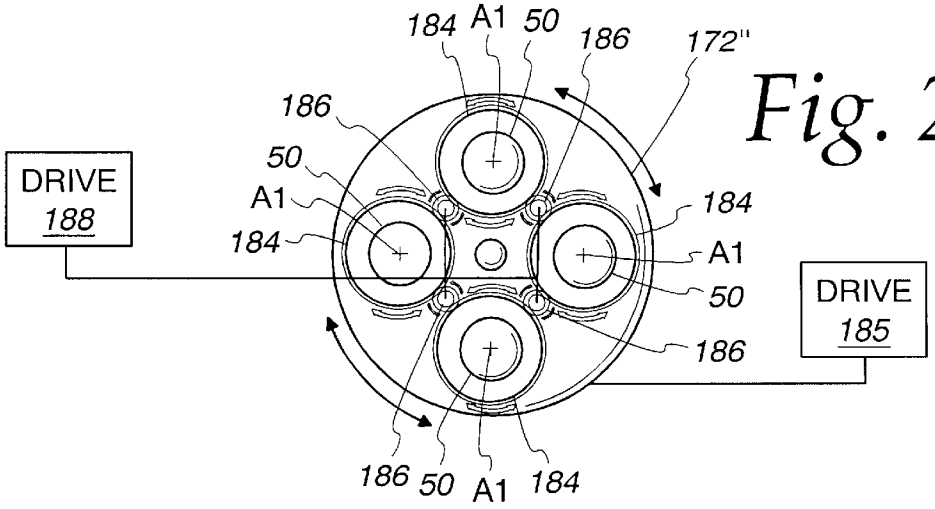

Fig. 26

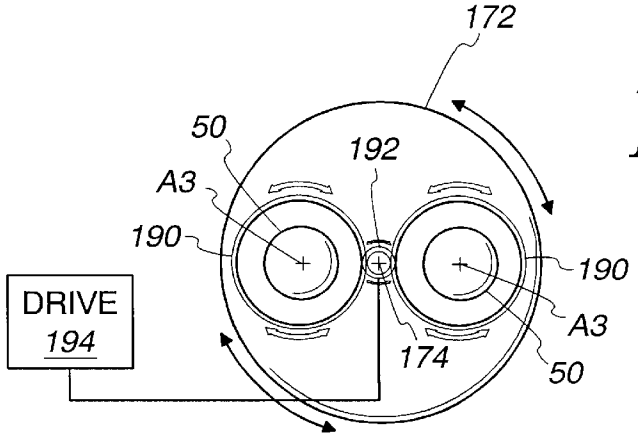

Fig. 27

MACHINE TOOL AND METHOD OF USING THE MACHINE TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to machine tools for processing discrete workpieces and, more particularly, to a machine tool through which individual workpieces can be strategically situated to facilitate processing on various sides thereof. The invention is also directed to a method of using the machine tool.

2. Background Art

In machining operations, it may be necessary to process most or all of the sides of a workpiece. In one conventional machining process, a first surface of a workpiece preform, nominally matched and dimensioned to the desired end configuration, is placed on a support to facilitate processing of the remaining surfaces thereon. Once processing of the remaining surfaces is completed, the first surface is separated from the support and exposed to allow the desired processing step(s) to be performed thereon.

Typically, a three-axis machine tool is employed to carry out the initial stage processing. Provision must then be made to engage and separate the workpiece from the support to expose the first surface to allow processing thereof.

In FIG. **1** herein, a conventional prior art vertical machining center is shown at **10**. The machining center **10** consists of a frame **12** on which a spindle head assembly **14** is mounted for guided vertical, Z-axis movement. The spindle head assembly **14** carries a rotary spindle **16** with a working tool **18** that processes discrete workpiece preforms **20**, which are mounted in a predetermined relationship on a pallet **22**.

The pallet **22** is in turn supported upon a table **24**, which is carried upon a slide assembly **25** consisting of stacked slides **26**, **28**. The lower slide **28** is mounted for guided movement relative to the frame **12** along the Y-axis. The upper slide **26**, to which the table **24** attaches, is mounted for guided movement relative to the lower slide **28** along the X-axis.

In a typical machining operation, the workpiece preforms **20** are placed on the pallet **22** so that a surface **30** on each of the workpiece preforms **20** bears upon a support surface **32** on the pallet **22**. Through controlled movement of the slides **26**, **28**, the workpiece preforms **20** are moved in the X-Y plane. At the same time, the working tool **18** moves along the Z-axis, following movement of the spindle head assembly **14**.

The workpiece preforms **20** are spaced from each other so that all but the supporting surfaces **30** are exposed to be processed by the working tool **18**. After the processing operation is concluded on the exposed portions of the workpiece preforms **20**, the workpiece preforms **20** are separated from the pallet **22** and reoriented, as by inversion, and placed against the palle surface **32** to expose the surfaces **30** so that an appropriate processing operation can be performed using the working tool **18**, or another tool in its stead.

The resituation of the workpiece preforms **20**, during processing thereof, may result in significant down time.

Further, it is common for the workpiece preforms **20** to be manually placed upon the pallet **22**, and for the workpiece preforms **20**, after processing, to be manually separated from the pallet **22**. This may result in significant inconvenience and time consumption.

Alternatively, it is known to use relatively complex and expensive automated setup systems with changers for removing an inactive table **24**/pallet **22** and substituting therefor a table **24**/pallet **22** with unprocessed workpiece preforms **20** thereon. The table **24**/pallet **22** exchange may take a significant amount of time. Also, a significant time investment may be involved by reason of the manual placement and removal of workpiece preforms **20** both prior to and after the performance of a machining operation.

SUMMARY OF THE INVENTION

The invention is directed to a method of processing a workpiece including the steps of: placing a first preform element in a first operative position on a first holder so that a first portion of the first preform element is exposed; performing a processing operation on the first portion of the first preform element with the first preform element in the first operative position; transferring the first preform element into a second operative position on a second holder; with the first preform element in the second operative position exposing a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position; and with the first preform element in the second operative position and the second portion of the first preform exposed, performing a processing operation on the second portion of the first preform element.

The second portion of the first preform element may be exposed by cutting the first preform element.

A single processing assembly may be used to perform the processing operations on both the first and second portions of the first preform element. Alternatively, a first processing assembly may be used to perform the processing operation on the first portion of the first preform element with a second processing assembly, operable independently of the first processing assembly, used to perform a processing operation on the second portion of the first preform element.

A second preform element can be placed in the first operative position on the first holder with the first preform element in the second operative position on the second holder.

A processing operation may be performed on the second preform element in the first operative position on the first holder with the first processing assembly while performing a processing operation on the first preform element in the second operative position on the second holder with the second processing assembly.

A second preform element can be provided on the first holder so that the first and second preform elements are simultaneously held by the first holder. After the step of performing a processing operation on the first portion of the first preform element by the first processing assembly, the first processing assembly and the second preform element may be relatively repositioned to allow the first processing assembly to perform a processing operation on the second preform element with the second preform element on the first holder.

The first processing assembly may have a first processing tool thereon. During the processing operation on the first portion of the first preform element, the processing tool may be moved along at least two orthogonal axes.

The second processing assembly may have a plurality of tools that are selectively indexed to an active position in which each of the plurality of tools in the active position performs a processing operation on the second portion of the first preform element.

The first preform element may be indexed on the first holder between a standby position and the first operative position.

The first preform element may be transferred directly from the first holder to the second holder.

The invention is also directed to a machine tool having a first holder, a second holder, and a processing system. The first holder maintains a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a machining operation can be performed on the first portion of the first preform element. The second holder maintains the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing. The processing system has at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position.

At least part of the at least one of the first and second holders may be movable guidingly relative to the other of the first and second holders to allow the first preform element to be transferred directly from the first holder to the second holder.

In one form, the at least one processing assembly is a first processing assembly that is repositionable relative to the first and second holders to allow the first processing assembly to perform a processing operation on the first preform element in the first operative position and a processing operation on the first preform element in the second operative position.

In one form, the first processing assembly has a first tool that is rotatable around a first axis for performing a processing operation and at least one part of the first processing assembly carrying the first tool is pivotable around a second axis that is transverse to the first axis to permit selective processing of the first preform element in the first and second operative positions for the first preform element.

The machine tool may be provided in combination with a first preform element.

The processing system may include a second processing assembly that is operable independently of the first processing assembly to perform a processing operation on the first preform element in the second operative position.

In one form, a cutting assembly, separate from the first and second processing assemblies, is provided for severing the first preform element on at least one of the first and second holders and thereby exposing the second portion of the first preform element.

The second processing assembly may include a turret with a plurality of tools that are selectively operable to perform a processing operation on the first preform element in the second operative position.

The first holder may be capable of holding a second preform element at the same time the first preform element is on the first holder.

The second holder may be capable of holding a second preform element at the same time the first preform element is on the second holder.

The first and second preform elements on the first holder may be selectively movable into the first operative position.

The first and second preform elements on the second holder may be selectively movable into the second operative position.

In one form, the at least part of the first processing assembly is movable guidingly along three orthogonal axes.

The turret may be translatable guidingly along two orthogonal axes.

The first processing assembly may include a tool receptacle, with the machine tool further having an automatic tool changer for selectively placing different tools in the tool receptacle.

A frame may be provided upon which the first and second holders and processing system are mounted.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a conventional machine tool for performing processing operations on a plurality of discrete parts;

FIG. **2** is a plan view of a machine tool, according to the present invention, including first and second holders for stock material and a processing assembly for performing a processing operation on stock material held by each of the first and second holders;

FIG. **3** is a front elevation view of the machine tool of FIG. **2**;

FIG. **4** is a side elevation view of the machine tool in FIGS. **2** and **3** with the second holder removed for clarity and with the processing assembly resituated from the position shown in FIGS. **2** and **3** and including a tool change mechanism for interchanging tools on the processing assembly;

FIG. **5** is a side elevation view of the machine tool as in FIG. **4** mounted to a slant bed frame;

FIG. **6** is a plan view of a modified form of machine tool, according to the present invention, including first and second holders each capable of holding multiple pieces of stock material and first and second processing assemblies, which are operable independently to perform a processing operation on stock material held by the first and second holders;

FIG. **7** is a front elevation view of the machine tool in FIG. **6** with the first processing assembly situated to perform a processing operation on the lowermost piece of stock on the first holder and the second processing assembly situated to perform a processing operation on the uppermost piece of stock on the second holder;

FIG. **8** is a side elevation view of the inventive machine tool configured as in FIG. **7** with the second holder removed for clarity;

FIG. **9** is a side elevation view of the machine tool as in FIG. **8** mounted on a slant bed frame;

FIG. **10** is a side elevation view of the machine tool in FIGS. **8** and **9** with the first processing assembly situated to perform a processing operation on the uppermost piece of material stock on the first holder and the second processing assembly situated to perform a processing operation on the uppermost piece of stock material on the second holder,

FIG. **11** is a view as in FIG. **10** with the processing assemblies situated to perform a processing operation on the lowermost pieces of stock material on the first and second holders;

FIG. **12** is a plan view of the machine tool in FIGS. **6–11** in the configuration of FIG. **11**;

FIG. **13** is a plan view of the machine tool in FIGS. **6–12** with the processing assemblies resituated and the first and second holders relatively repositioned to allow direct transfer of a piece of stock material from one holder to the other;

FIG. **14** is a plan view of the machine tool in FIGS. **6–13** with the first and second processing assemblies situated to simultaneously perform processing operations on a piece of stock material on the first holder;

FIG. **15** is a view as in FIG. **14** with the processing assembly situated to simultaneously perform a processing operation on a piece of stock material on the second holder;

FIG. **16** is a plan view of a further modified form of machine tool, according to the present invention, including first and second holders, each with an indexable magazine for holding a plurality of pieces of stock material, and with first and second processing assemblies as in the machine tool in FIGS. **6–15**;

FIG. **17** is a front elevation view of the machine tool in FIG. **16**;

FIG. **18** is a side elevation view of the machine tool in FIGS. **16** and **17**;

FIG. **19** is a view as in FIG. **18** with an automatic tool changer, for exchanging tools with at least one of the processing assemblies, removed for clarity;

FIG. **20** is a side elevation view of the machine tool as in FIG. **18** and mounted on a slant bed frame;

FIG. **21** is a plan view of the machine tool in FIGS. **16–20** showing a cutting tool positioned to sever stock material held between the first and second holders;

FIG. **22** is a plan view of the machine tool in FIGS. **16–21** with the first and second processing assemblies situated to perform processing operations on pieces of stock material on the first and second holders;

FIG. **23** is a view as in FIG. **22** with the processing assemblies reoriented to perform processing operations on different portions of the stock material on the first and second holders;

FIG. **24** is a plan view of the machine tool in FIGS. **16–23** and with one of the processing assemblies situated to effect tool exchange through an automatic tool changer;

FIG. **25** is an enlarged, side elevation view of one form of indexable magazine for holding multiple pieces of stock material on one of the first and second holders on the machine tool in FIGS. **16–24**;

FIG. **26** is a view as in FIG. **25** of a modified form of indexable magazine; and

FIG. **27** is a view as in FIGS. **25** and **26** of a still further modified form of indexable magazine.

DETAILED DESCRIPTION OF THE DRAWINGS

One form of machine tool, according to the present invention, is shown in FIGS. **2–5** at **36**. The machine tool **36** consists of a frame **38** upon which first and second holders **40**, **42** are mounted. The frame **38** also supports a processing system **44**, which in this case includes a single processing assembly **46**. The frame **38** further supports a cutting assembly **48**.

The holders **40**, **42** have a similar construction. Exemplary holder **40** is designed to hold individual workpiece/preform elements, nominally dimensioned to the desired size of a completed workpiece, in a first operative position. Throughout, the workpiece/preform element is shown as an elongate piece of bar stock **50**. The workpiece/preform element could be a cast part of intricate shape, an extruded bar that is either solid or hollow, or virtually any shape or constitution conventionally processed. In the event that pieces of bar stock material **50** are utilized, the holder **40** has an indexer **52** which shifts the bar stock **50** from a standby position at a feed end **54** to and from a working end **56** at which a free end portion **58** of the bar stock **50** is exposed for processing thereof.

The first holder **40** is translatable guidingly relative to the frame **38** along the X-axis. A central axis **60** of the bar stock **50** is parallel to the line of guided movement of the holder **40**.

The second bar holder **42** receives the piece of bar stock **50** so that the central axis **60** of the piece of bar stock **50** in a second operative position on the second holder **42** is coincident with the axis **60** of the piece of bar stock **50** with the piece of bar stock **50** in the first operative position on the first holder **40** and coincident with operating axes defined by the first and second holders **40**, **42**.

The first and second holders **40**, **42** each include a base **62**, **64** of similar construction. Exemplary base **64** has a T-shaped receptacle **66** to accept a correspondingly configured guide element **68** on the frame **38** so as to permit guided movement of the base **64** along the frame **38** parallel to the X-axis. The base **62** has a similar construction and is mounted in similar fashion to the frame **38**. With this arrangement, the first and second holders **40**, **42** can be moved relative to each other to allow the bar stock **50** to be transferred directly between the first and second holders **40**, **42**.

The processing assembly **46** is carried by a slide assembly at **70** consisting of a first slide **72** connected to the frame **38** for guided movement relative to the frame **38** along the Z-axis, a second slide **74** mounted to the first slide **72** for guided movement relative to the first slide **72** along the X-axis, and a third slide **76** mounted to the second slide **74** for guided movement relative to the second slide **74** along the Y-axis. Each of the slides **72**, **74**, **76** can be mounted to the frame **38**, and each other, through a connection similar to the aforementioned connection including the receptacle **66** and guide element **68**. Other guide arrangements well known to those skilled in the art are contemplated. Virtually any arrangement that allows relative, guided, translatory movement between two elements could be used between the slides **72**, **74**, **76**.

The processing assembly **46** is mounted to the slide **76** for pivoting movement about a vertical axis **78**, transversely to the axis **60**, preferably through 360°. A lesser degree of pivoting movement is also contemplated. The processing assembly **46** includes a rotary spindle **80** rotated by a drive **82** and having a receptacle **84** for a working tool **86** which can be selectively projected toward the first and second holders **40**, **42** by such pivoting movement.

The slides **72**, **74**, **76** are relatively dimensioned and repositionable to allow the working tool **86** to process the free end surface **88** of the bar stock **50** in the first operative position on the first holder **40**. By repositioning the slides **72**, **74**, **76** and pivoting the processing assembly **46** about the axis **78**, the working tool **86** can process the exposed peripheral surface **90** on the piece of bar stock **50** in the first operative position on the first holder **40**.

In a typical operation, the bar stock **50** is placed on the first holder **40** and indexed to expose the free end portion **58** thereof on which processing is to be carried out. When processing of the exposed free end portion **58** is completed, including any processing that is required on the surfaces **88**, **90**, the slide **76** is retracted from the FIG. **2** position, in the direction of the arrow **92** i.e. along the Y-axis, to allow the transfer of the bar stock **50** from the first holder **40** to the second holder **42**. This can be accomplished by a direct transfer, as previously described, or optionally through a conventional type transfer mechanism **93**.

The bar stock **50** in the first holder **40** can be nominally matched to the desired length of the completed workpiece. In that event, upon completion of the transfer, the end surface **94** of the bar stock **50**, which is not exposed for processing with the bar stock **50** in the first operative position, becomes exposed for processing with the bar stock

50 in the second operative position from the second holder 42. Processing on the end surface 94 can be carried out by repositioning the slide assembly 70 and pivoting the processing assembly 46 around the axis 78 to place the working tool 86 in a position to engage the end surface 94.

In the event that multiple work pieces are to be formed from a single piece of the bar stock 50, the bar stock 50 has a length that is a multiple of the length of the completed workpieces, and the end surface 94 that is processed with the bar stock 50 in the second operative position on the second holder 42 is exposed by cutting the bar stock through the cutting assembly 48.

The cutting assembly 48 includes cutoff tool 96 carried on a slide assembly 98. The slide assembly 98 include a first slide 100 which is guided along the frame 38 parallel to the X-axis. A second slide 102, upon which the cutting assembly 48 is attached, is mounted to the first slide 100 for guided movement relative to the first slide 100 parallel to the Y-axis. With the bar stock 50 on the second holder 42, the cutting assembly 48 is repositioned through the slide assembly 98 to locate the cutoff tool 96 at the desired lengthwise cutoff position on the bar stock 50. The cutoff tool 96 then severs the bar stock 50, as by movement of the slide 102 along the Y-axis, to thereby expose the end surface 94 for processing.

An indexer 106 may be provided to rotationally position the bar stock 50 around the axis 60 on the first holder 40. A like indexer 108 may be provided on the second holder 42 to perform the same function. This allows the full peripheral surface 90 to be processed using the working tool 86.

The machine tool 36 may further include an auto tool changer 110 with a plurality of pods 112 each containing a working tool 86. The tool changer 110 includes an indexable turret/magazine 114 which places the desired pod 112 in an exchange position which allows a tool 86 to be exchanged between the pod 112 and the spindle 80 on the processing assembly 46.

In FIG. 5, the machine tool 36 is shown mounted on an inclined surface 116 on a slant bed frame 118 of the type disclosed in my U.S. Pat. No. 5,820,098.

To hold the bar stock 50, each of the holders 40, 42 may be provided with a chuck 120, 122, respectively. The chucks 120, 122 can be selectively opened and clamped to the bar stock, as required to hold the bar stock 50 for processing and release the bar stock 50 for transfer.

In operation, the bar stock 50 is loaded on the first holder 40 and indexed lengthwise to expose the free end portion 58 for processing. Processing is carried out through the processing assembly 46, at the conclusion of which the processing assembly 46 is retracted to allow the transfer of the bar stock 50 to the second holder 42. If the bar stock 50 that is transferred is significantly longer than the desired length of the completed workpiece, the cutoff tool 96 is used to sever the bar stock 50 to the desired length. The cutting assembly 48 is then retracted to allow the processing assembly 46 to complete processing upon the end surface 94, whereupon the bar stock 50 is released from the second holder 42 and delivered to an appropriate location, as for stocking or for further processing.

In FIGS. 6–9, a modified form of machine tool is shown at 126. The basic components on the machine tool 126 are the same as on the machine tool 36 and are numbered consistently. The machine tool 126 includes the frame 38 and the processing assembly 46 and the slide assembly 70 therefor. The automatic tool changer 110 allows interchange of working tools 86 on the processing assembly 46.

There are two primary differences between the machine tool 126 in FIGS. 6–9 and the machine tool 36 in FIGS. 2–5.

The machine tool 126 has first and second holders 128, 130 for the bar stock 50 corresponding to the holders 40, 42 on the machine tool 36. Whereas the holders 40,42 accommodate a single piece of bar stock 50, the first and second holders 128, 130 each accommodate multiple pieces of bar stock 50. In this case, four pieces of bar stock 50 are accommodated by each holder 128, 130, with there being a like number of chucks 132, 134 on the holders 128, 130 to maintain the pieces of bar stock 50 in the operative position on the holders 128, 130 in vertically stacked relationship. On the first holder 128, an indexer 136, corresponding to the indexer 52 on the machine tool 36, is provided to controllably shift the bar stock 50 lengthwise along the holder 128. A separate indexer 138 incrementally pivots the pieces of bar stock 50 about their central axes 60. With this arrangement, the processing assembly 46 can be moved vertically, i.e. along the Z-axis, to process the free end portions 58 of the bar stock 50 exposed at the holder 128.

The second holder 130 may have a configuration similar to the first holder 128, including indexers (not shown) corresponding to, and functioning in the same manner as, the indexers 136, 138. The chucks 132, 134 are axially aligned to allow the direct transfer of pieces of bar stock bar 50 directly between the holders 128, 130. As in the prior embodiment, a transfer mechanism (not shown), corresponding to the transfer mechanism 92, could be used.

The second principal difference between the machine tool 126 and the machine tool 36 is that the processing system 139 on the machine tool 126 includes the first processing assembly 46 and a second processing assembly at 140. The processing assembly at 140 includes a tool turret 142 mounted on a support 144 for pivoting movement around an axis 146. The support 144 in turn is mounted on a slide assembly at 148. The slide assembly 148 includes a first slide 150 mounted to the frame 38 for guided movement relative to the frame along the Z-axis. A second slide 152 is mounted to the first slide 150 for guided movement relative to the first slide 150 along the X-axis. A third slide 154, to which the support 144 is attached, is movable guidingly relative to the second slide 152 along the Y-axis. With this arrangement, a desired working tool T carried on the turret 142 can be indexed to an active position to process the free end surfaces 88, 94 and the exposed peripheral surface 90 on the bar stock 50.

The slide assembly 148 can be constructed so that the tools T on the processing assembly 140 can be situated to perform a processing operation on the bar stock 50 in the operative position on either holder 128, 130. The slide assembly 70 can be constructed so that the working tool 96 on the processing assembly 46 likewise is capable of performing a processing operation on the bar stock 50 in the operative position on either holder 128, 130. Some of the processing options for the machine tool 126 are shown in FIGS. 10–15.

In FIGS. 11 and 12, the processing assemblies 46, 140 are situated to simultaneously perform an operation on the exposed peripheral surface 90 of the lowermost piece of bar stock 50 in the operative position on the first holder 128 and second holder 130, respectively.

It is also possible to configure the processing assemblies 46, 140 so that one of the free end surfaces 88, 94 is being processed on the bar stock 50 on one holder 128, 130 at the same time the exposed peripheral surface 90 on the bar stock 50 on the other holder 128, 130 is being processed.

In FIG. 10, a similar arrangement is shown, however, the processing assemblies 46, 140 are situated to perform a

processing operation on the uppermost piece of bar stock **50** in the operative position on the first and second holder **128**, **130**.

In FIG. **14**, the processing assemblies **46**, **140** are situated to simultaneously perform a processing operation on a piece of bar stock **50** in an operative position on the first holder **128**. The processing assembly **46** is situated so that the working tool **86** thereon performs a processing operation on the free end surface **88** of the piece of bar stock **50** simultaneously as the active tool T on the processing assembly **140** performs a processing operation on the exposed peripheral surface **90** on the bar stock **50**.

In FIG. **15**, the machining assemblies **46**, **140** are situated so that the working tool **86** on the processing assembly **46** performs a processing operation on the end surface **94** of the bar stock **50** in the operative position on the second holder **130** simultaneously as the active tool T on the processing assembly **140** is performing a processing operation on the exposed peripheral surface **90** on the bar stock **50** with the bar stock **50** in the operative position on the second holder **130**.

In FIG. **13**, the processing assembly **46** is shown in position to exchange tools with the tool changer **110** while the second holder **130** has been advanced towards the first holder **128** to engage and pick up the bar stock **50** from the first holder **128**. It should be noted that while the first holder **128** is actually stationary relative to the frame **38**, it could be movable along the X-axis to facilitate bar stock transfer.

As shown in FIG. **9**, the machine tool **126** can be mounted on the slant bed frame **118**.

With the machine tool **126**, efficiency may be gained by having the ability to process several pieces of bar stock **50** on the first holder **128** before transfer to the second holder **130** is required. Further efficiency is potentially built in by simultaneously performing processing operations on the pieces of bar stock **50** on both the first and second holders **128**, **130**, or by simultaneously processing a single piece of bar stock **50** with both processing assemblies **46**, **140**.

In FIGS. **16–27**, a further modified machine tool, according to the present invention, is shown at **166**. The machine tool **166** has the same basic configuration as the machine tool **126**, with the exception of the configuration of first and second holders, **168**, **170**, corresponding to the holders **128**, **130** on the machine tool **126**. Parts on the machine tool **166** that are the same as those on the machine tool **126** will be numbered the same.

The first holder **168** functions in the same manner as the first holder **128** in terms of holding bar stock **50** in an operative position so that processing operations can be performed thereon. The first holder **168** carries a plurality of pieces of bar stock **50** and has a magazine **172** thereon which is pivotable about a central axis **174** to thereby selectively, serially bring the pieces of bar stock **50** from an inactive position into an operative position at the same location for processing by the processing assembly **46** or the processing assembly **140**. This obviates the need to move the machining assemblies **46**, **140** in the same manner as required for the machine tool **126** with the multiple pieces of bar stock **50** in a fixed position on the machine tool **126**.

The second holder **170** is shown to have the capacity to hold a single piece of bar stock **50**. However, the second holder **170** can be constructed to simultaneously receive multiple pieces of bar stock **50** from the first holder **168** in a transfer operation.

The slide assemblies **70**, **98** have the same construction as they do on the machine tool **126**, while processing operations are performed on the pieces of bar stock **50** in the operative position on the first and second holders **168**, **170** in the manner previously described.

Different constructions for the magazine **172** are shown at **172'**, **172"** in FIGS. **25** and **26**. In FIG. **25**, the magazine **172'** has a drive **176** for pivoting the entire magazine **172'** around an axis **174**. An indexing gear **178**, pivoted by a separate drive **180** selectively in opposite directions around the axis **174**, is geared to bar stock holders **182** around the periphery thereof. Pivoting of the gear **178** simultaneously pivots the holders **182** around their respective axes A to effect indexing so as to present the desired surface of the piece of bar stock **50** to the machining assemblies **46**, **140**. The use of six bar stock holders **182** is a design choice, as the basic concept can be practiced with virtually any number of bar stock holders **182**, including a single bar stock holder **182**.

In FIG. **26**, the magazine **172"** is shown with four bar stock holders **184**. The magazine **172"** is pivotable about the axis **174** through selective operation of a drive **185**. The bar stock holders **184** are keyed to each other through gears **186**, each in mesh with a pair of holders **184**. By rotating the gears **186**, the holders **184** are simultaneously pivoted around their axes Al to effect indexing thereof. One or all of the gears **186** may be rotated by a drive **188**.

As shown in FIG. **27**, the magazine **172**, previously described, operates similarly to the magazine **172'**, with the exception of their being only two bar stock holders **190** corresponding to the bar stock holders **184**. A gear **192** driven by a drive **194** selectively in opposite directions, causes simultaneous pivoting of the bar stock holders **190** about their axes A2.

It is possible with all of the magazines **172**, **172'**, **172"**, and particularly with the magazine **172**, to perform separate processing steps on more than one piece of bar stock **50** with one or both of the processing assemblies **46**, **140** without indexing the magazine **172**, **172'**, **172"**. That is, multiple pieces of bar stock **50** could both be in the operative position at the same time on one or both of the holders **168**, **170**.

In FIG. **20**, the machining tool **166** is shown mounted upon the slant bed frame **118**.

In FIG. **21**, the machine tool **166** is configured to allow transfer of the bar stock **50** between the first and second holders **168**, **170**.

In FIG. **22**, the machine tool **166** is configured with the working tool **86** on the processing assembly **46** performing a processing operation on the peripheral surface **90** of a piece of bar stock **50** in the operative position on the first holder **168**. Simultaneously, an active tool T on the turret **152** on the processing assembly **140** is performing a processing operation on the end surface **94** of a piece of bar stock **50** in the operative position on the second holder **170**.

In FIG. **23**, the working tool **86** on the processing assembly **46** is shown performing a processing operation on the free end surface **88** of bar stock **50** in the operative position on the first holder **168**, while an active tool T on the turret **142** on the processing assembly **140** is performing a processing operation on the exposed peripheral surface **90** on the bar stock **50** in an operative position on the second holder **170**.

In FIG. **24**, the processing assembly **140** is positioned to perform a processing operation as in FIG. **22**, with the processing assembly **46** retracted and situated to exchange tools with the tool changer **110**.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

What is claimed is:

1. A machine tool comprising:

a first holder for maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a processing operation can be performed on the first portion of the first preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position,

wherein the at least one processing assembly comprises a first processing assembly that is repositionable relative to the first and second holders to allow the first processing assembly to perform a processing operation on the first preform element in the first operative position and a processing operation on the first preform element in the second operative position,

wherein the first processing assembly has a first tool that is rotatable around a first axis for performing a processing operation and at least part of the first processing assembly carrying the first tool is pivotable around a second axis that is transverse to the first axis to permit selective processing of the first preform element in the first and second operative positions for the first preform elements,

wherein the first holder has an operating axis and the second axis is transverse to the operating axis,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

2. The machine tool according to claim 1 wherein at least part of at least one of the first and second holders is movable guidingly relative to the other of the first and second holders to allow the first preform element to be transferred directly from the first holder to the second holder.

3. The machine tool according to claim 1 in combination with the first preform element.

4. The machine tool according to claim 3 wherein the first preform element comprises an elongate piece of bar stock.

5. The machine tool according to claim 1 wherein the processing system comprises a second processing assembly that is operable independently of the first processing assembly to perform a processing operation on the first preform element in the second operative position and movable relative to the first processing assembly along the operating axis.

6. The machine tool according to claim 5 wherein the second processing assembly comprises a turret with a plurality of tools that are selectively operable to perform a processing operation on the first preform element in the second operative position.

7. The machine tool according to claim 6 wherein the turret is translatable guidingly along two orthogonal axes.

8. The machine tool according to claim 1 wherein the first holder is capable of holding a second preform element at the same time the first preform element is on the first holder.

9. The machine tool according to claim 1 wherein the second holder is capable of holding a second preform element at the same time the first preform element is on the second holder.

10. The machine tool according to claim 1 further comprising a transfer mechanism independent of the first and second holders for transferring a preform element held by one of the first and second holders to the other of the first and second holders.

11. The machine tool according to claim 1 further comprising an indexer for selectively rotationally positioning a preform element around the operating axis.

12. A machine tool comprising:

a first holder for maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a processing operation can be performed on the first portion of the first preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing;

a processing system comprising at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position,

wherein the at least one processing assembly comprises a first processing assembly that is repositionable relative to the first and second holders to allow the first processing assembly to perform a processing operation on the first preform element in the first operative position and a processing operation on the first preform element in the second operative position,

wherein the first processing assembly has a first tool that is rotatable around a first axis for performing a processing operation and at least part of the first processing assembly carrying the first tool is pivotable around a second axis that is transverse to the first axis to permit selective processing of the first preform element in the first and second operative positions for the first preform elements,

wherein the first holder has an operating axis and the second axis is transverse to the operating axis,

wherein the processing system comprises a second processing assembly that is operable independently of the first processing assembly to perform a processing operation on the first preform element in the second operative position and movable relative to the first processing assembly along the operating axis; and

a cutting assembly movable relative to the first and second processing assemblies along the operating axis for severing the first preform element on at least one of the first and second holders and thereby exposing the second portion of the first preform element.

13. A machine tool comprising:

a first holder for maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a machining operation can be performed on the first portion of the first preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising at least one processing assembly for performing a processing operation on the

first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position,

wherein the at least one processing assembly comprises a first processing assembly that is repositionable relative to the first and second holders to allow the first processing assembly to perform a processing operation on the first preform element in the first operative position and a processing operation on the first preform element in the second operative positions,

wherein the first processing assembly has a first tool that is rotatable around a first axis for performing a processing operation and at least part of the first processing assembly carrying the first tool is pivotable around a second axis that is transverse to the first axis to permit selective processing of the first preform element in the first and second operation positions for the first preform element,

wherein the at least part of the first processing assembly is movable guidingly along three orthogonal axes,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

14. A machine tool comprising:

a first holder for maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a machining operation can be performed on the first portion of the first preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising a least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position,

wherein the at least one processing assembly comprises a first processing assembly that is repositionable relive to the first and second holders to allow the first processing assembly to perform a processing operation on the first preform element in the first operative position and a processing operation on the first preform element in the second operative position,

wherein the first processing assembly comprises a tool receptacle and the machine tool further comprises an automatic tool changer for selectively placing different tools in the tool receptacle,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

15. A machine tool comprising:

a first holder for simultaneously maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a processing operation can be performed on the first portion of the first preform element and a second preform element in a second operative position wherein a first portion of the second preform element is exposed so that a processing operation can be performed on the first portion of the second preform element;

a second holder for maintaining the first preform element in a third operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position, the first portion of the second preform element in the second operative position, and the second portion of the first preform element in the third operative position,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

16. A machine tool comprising:

a first holder having a portion for holding first and second preforms that is movable to selectively place the first preform element in a first operative position at a first location wherein a first portion of the first preform element is exposed so that a machining operation can be performed on the first portion of the first preform element and the second preform in an operative position at the first location wherein a first portion of the second preform element is exposed so that a machining operation can be performed on the first portion of the second preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

17. A machining tool comprising:

a first holder for maintaining a first preform element in a first operative position wherein a first portion of the first preform element is exposed so that a machining operation can be performed on the first portion of the first preform element;

a second holder for maintaining the first preform element in a second operative position wherein a second portion of the first preform element that is not exposed for processing with the first preform element in the first operative position is exposed for processing; and

a processing system comprising at least one processing assembly for performing a processing operation on the first portion of the first preform element in the first operative position and the second portion of the first preform element in the second operative position,

wherein the at least one processing assembly comprises a first processing assembly that is repositionable relative

to the first and second holders along three orthogonal axes,

wherein the first holder has first and second ends spaced axially relative to the operating axis and a workpiece can be fed axially relative to the operating axis up to and through the first end of the first holder and to and through the second end of the first holder so as to be exposed for processing by the processing system.

18. The machine tool according to claim **17** wherein the first holder is capable of maintaining a second preform element in an operative position simultaneously as the first preform is maintained in the first operative position so that first and second preforms can be selectively processed by the processing system.

* * * * *

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Miyano

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(54) **METHOD AND APPARATUS FOR WITHDRAWING BAR STOCK FROM A BAR STOCK FEEDER**

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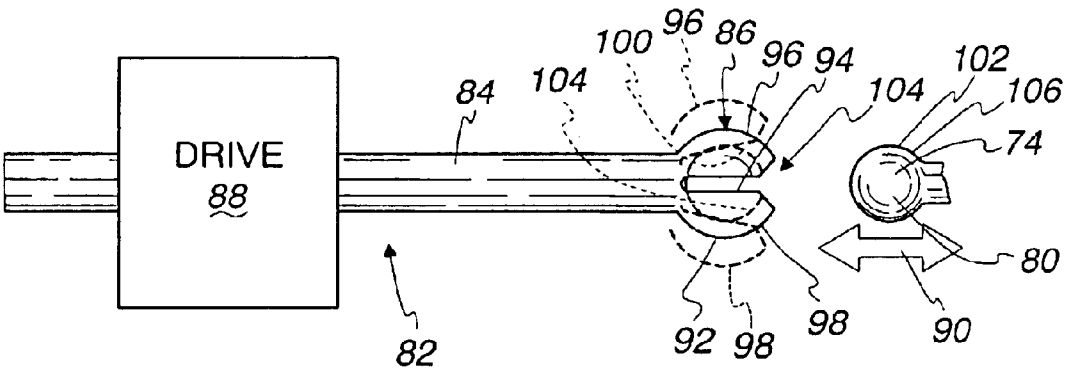
(57) **ABSTRACT**

A method of processing a piece of bar stock material having spaced ends and a predetermined diameter and including the steps of: attaching an adaptor to one end of the piece; directing the piece into a feeder sleeve bounding an internal passageway; moving the piece in the internal passageway from an upstream end toward a downstream end so as to expose a part of the piece for processing; performing at least one processing step on the exposed part of the piece; engaging a retrieval assembly with the adaptor; extending at least a part of the retrieval assembly into the internal passageway from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece within the internal passageway.

27 Claims, 6 Drawing Sheets



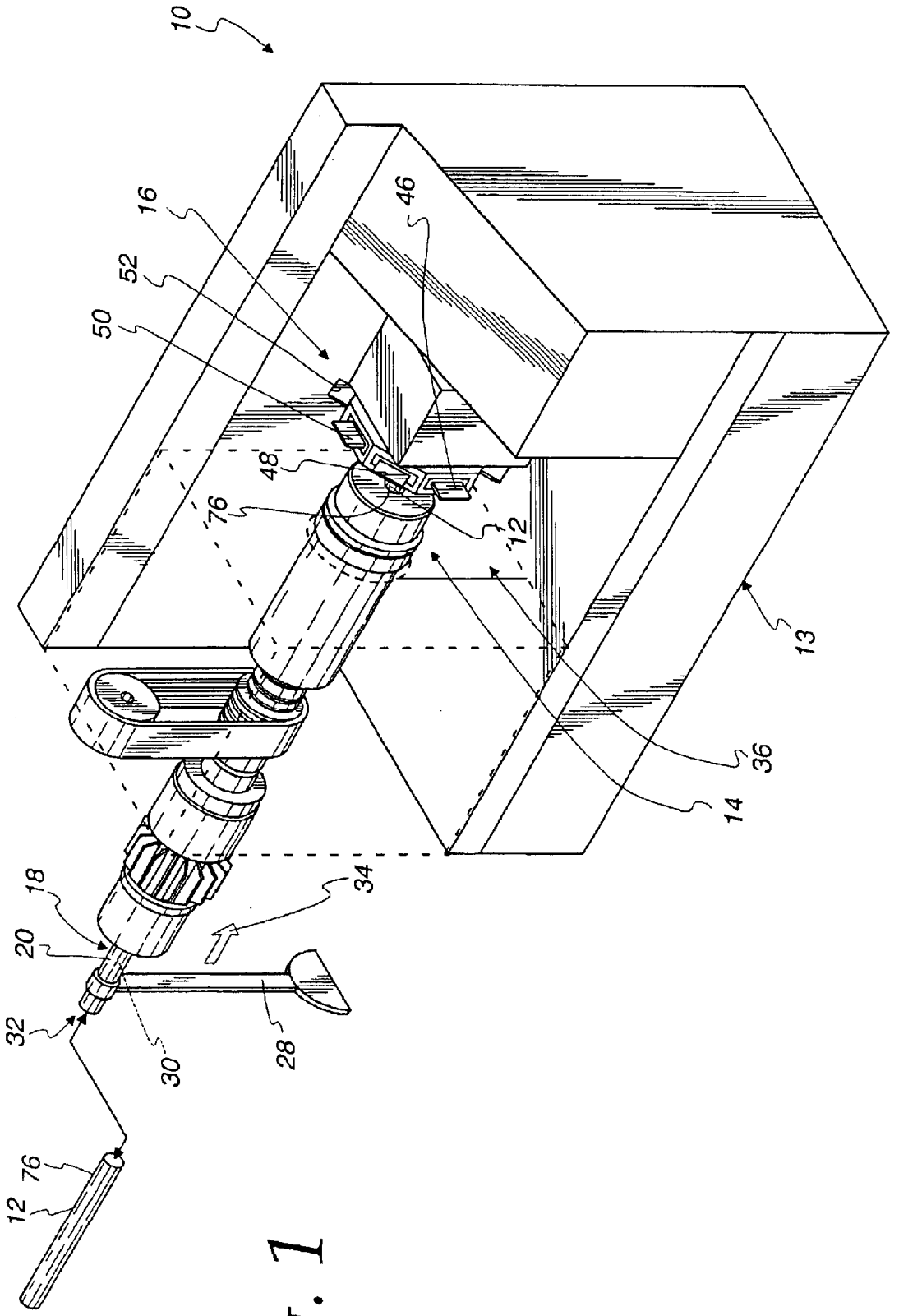


Fig. 1

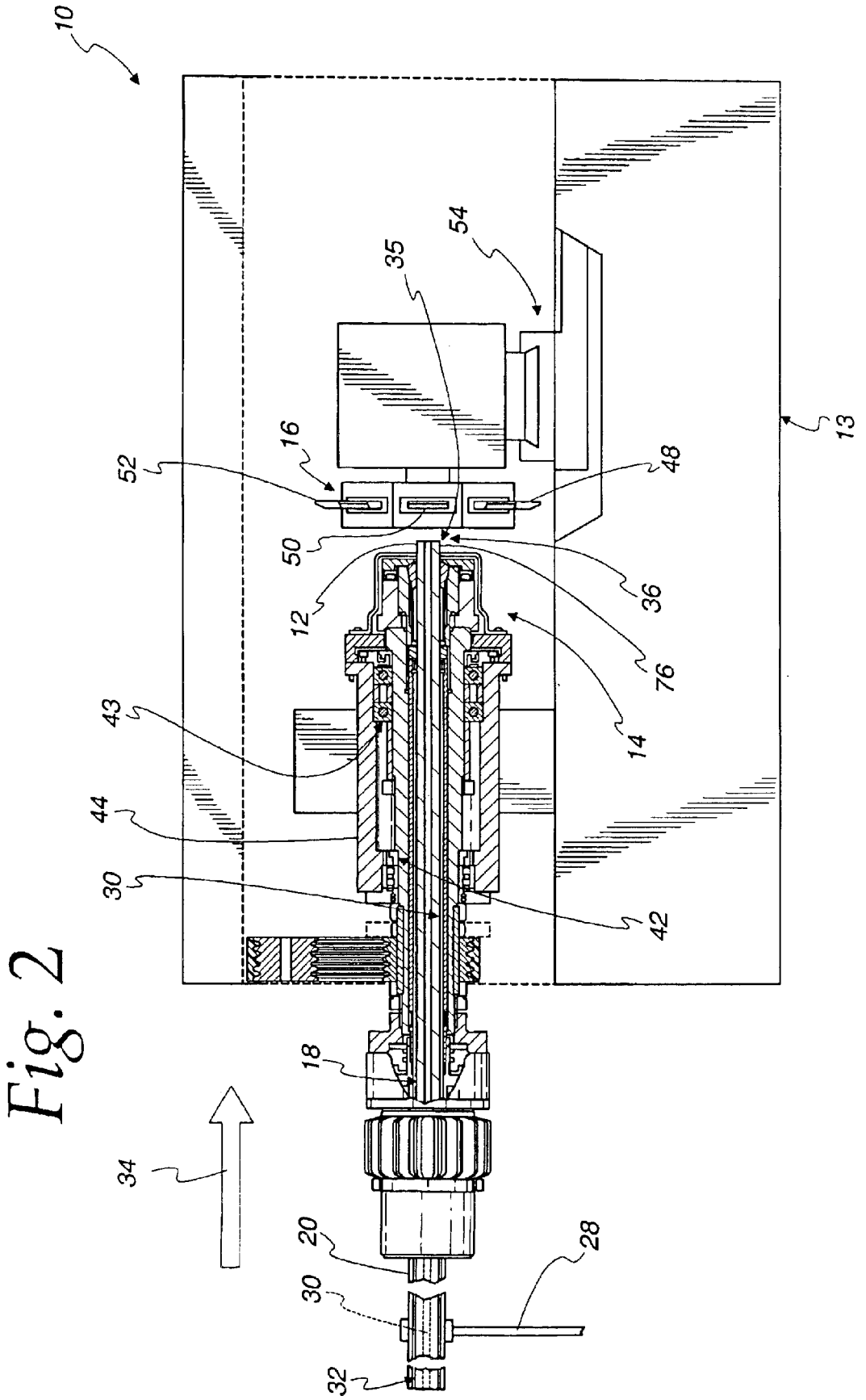
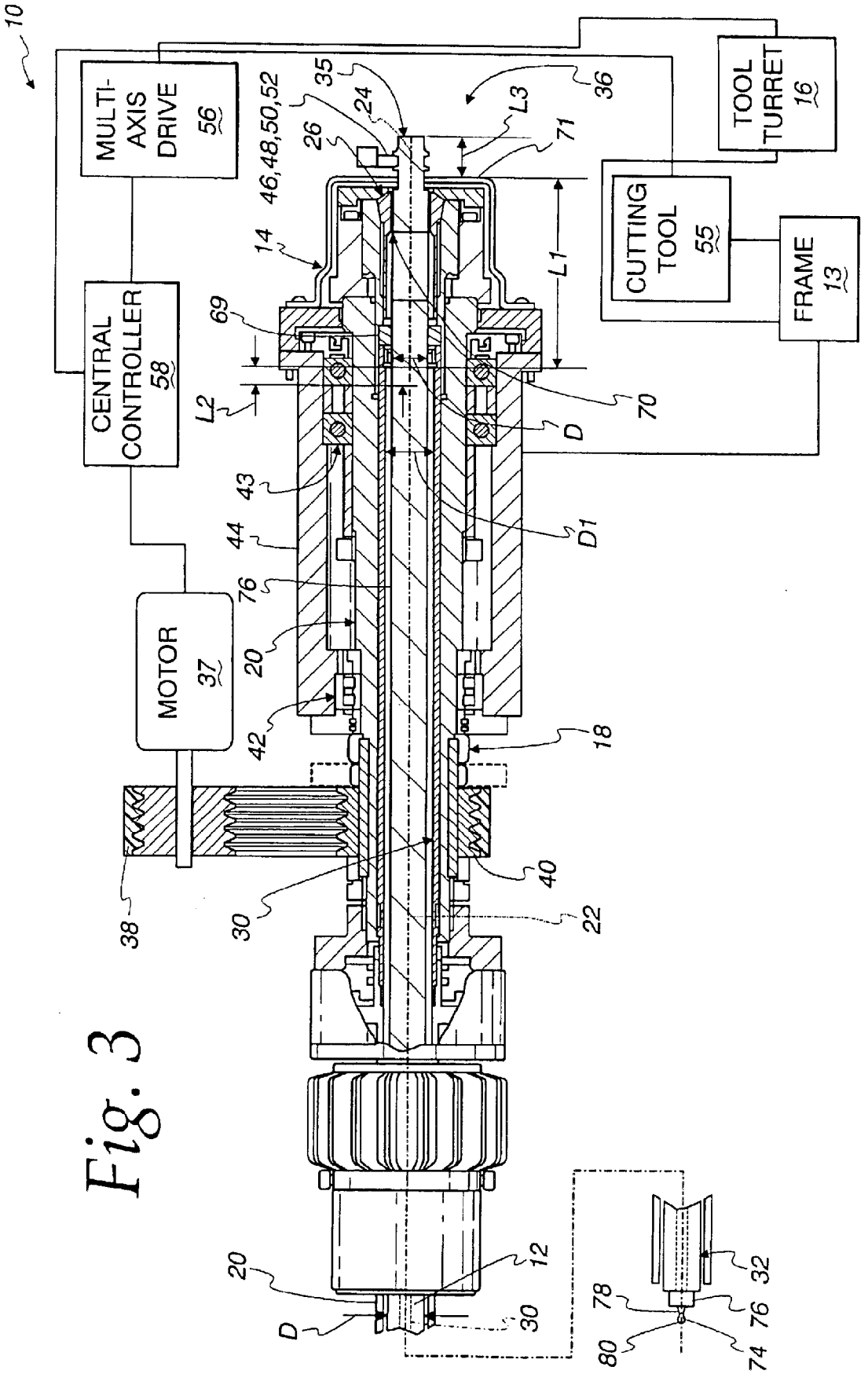


Fig. 2


10
MULTI-AXIS DRIVE 56
CENTRAL CONTROLLER 58
MOTOR 37
TOOL TURRET 16
CUTTING TOOL 55
FRAME 13
46,48,50,52
35
24
26
36
L3
71
14
L1
69
L2
D
70
43
D1
44
76
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80
74

Fig. 3

Fig. 4
(Prior Art)

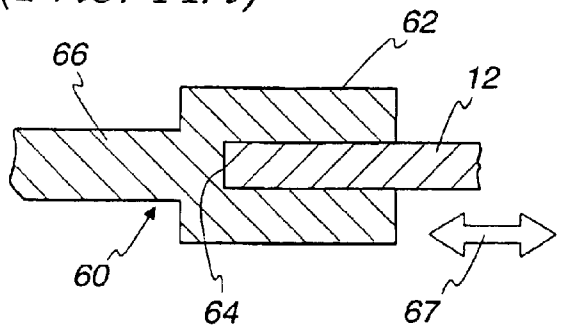


Fig. 5
(Prior Art)

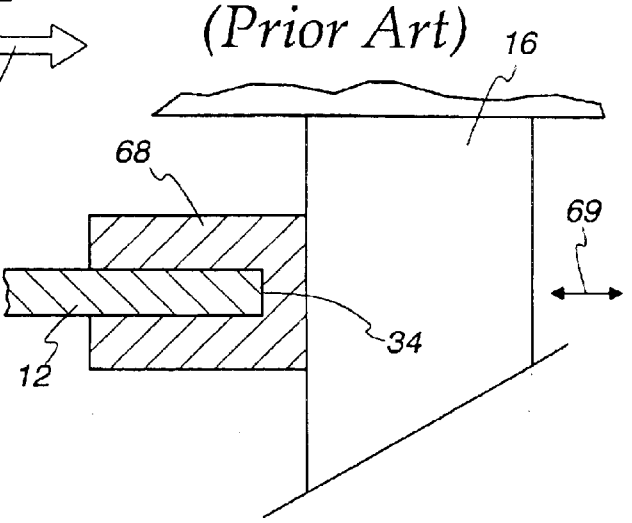


Fig. 6

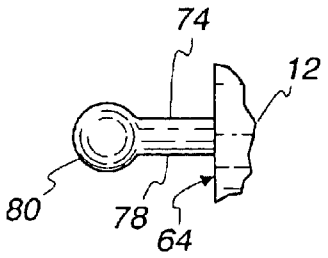


Fig. 7

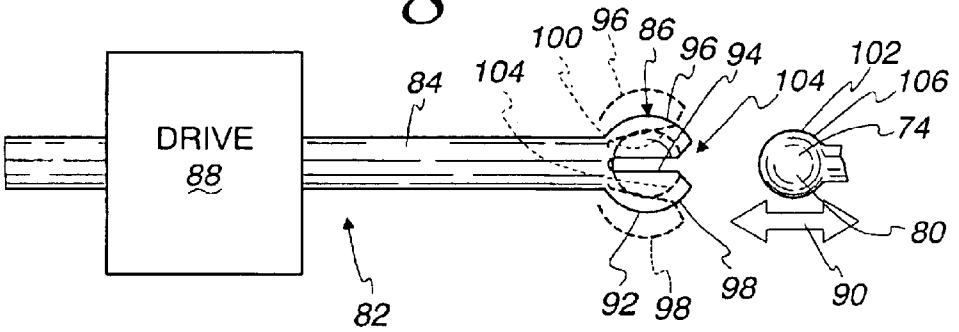


Fig. 8

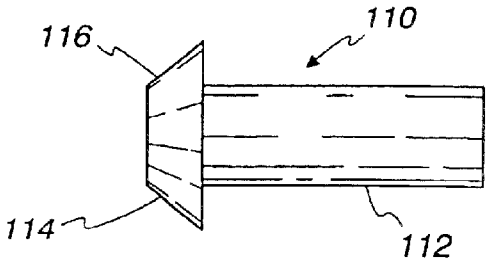


Fig. 9

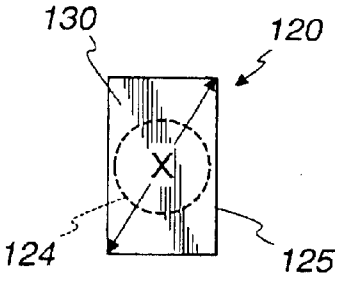


Fig. 10

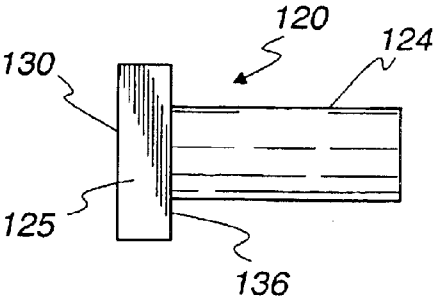


Fig. 11

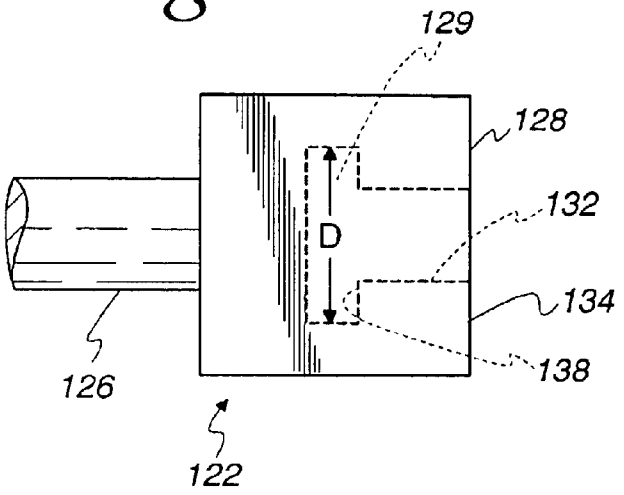


Fig. 12

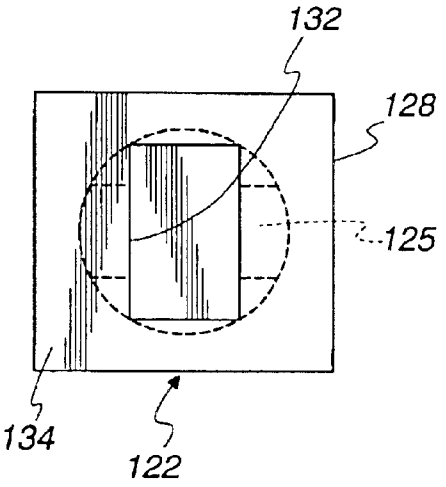


Fig. 13

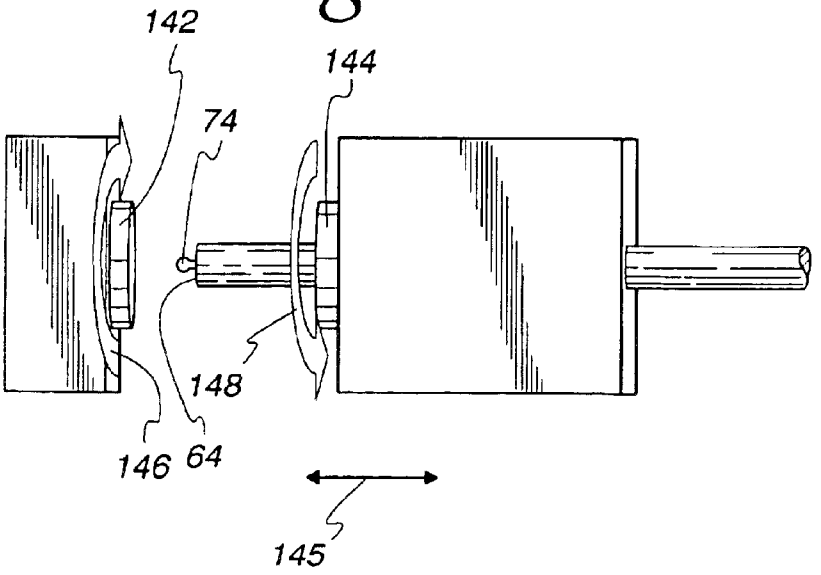


Fig. 14

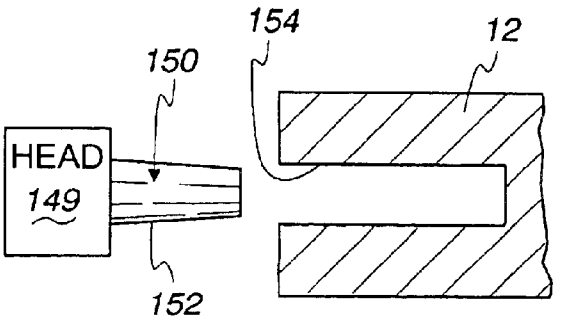


Fig. 15

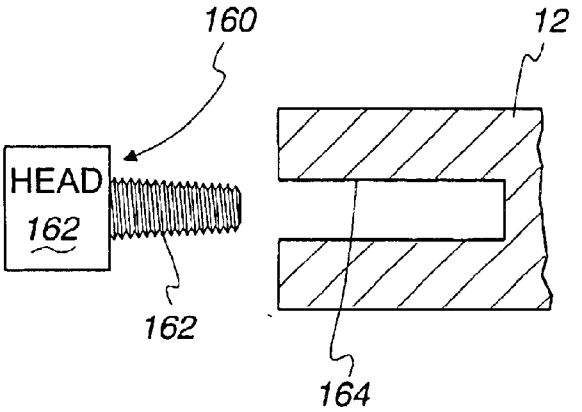


Fig. 16

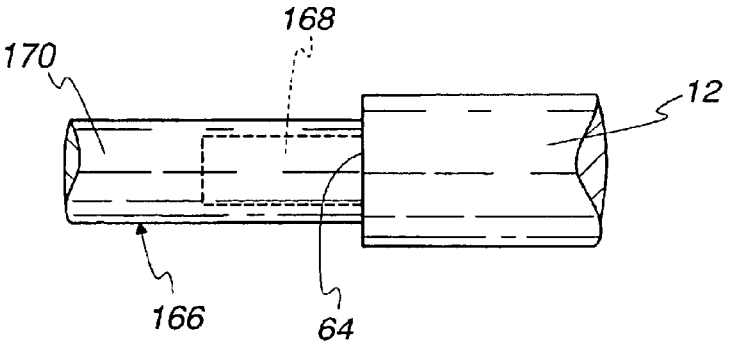
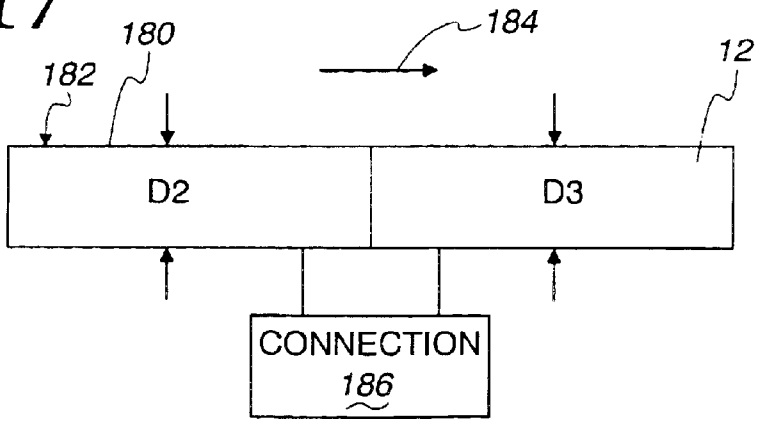


Fig. 17



METHOD AND APPARATUS FOR WITHDRAWING BAR STOCK FROM A BAR STOCK FEEDER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to feeder assemblies for delivering bar stock for processing by a machine tool and, more particularly, to a method and apparatus for removing unprocessed bar stock from the feeder assembly.

2. Background Art

It is known to process bar stock using different types of machine tools. In a typical system, a feeder assembly is utilized through which bar stock is delivered stepwise to a processing station at which any of a number of different operations can be performed thereon. As but one example, the bar stock is advanced to expose an end portion which is processed and cut from the remaining portion of the bar. The remaining portion of the bar is then advanced to repeat the same and/or a different processing step. This procedure is carried on repetitively until the bar length is reduced to a point that the remaining portion cannot be converted by processing into a usable form.

In one such system, the feeder assembly has a through passageway which is coaxial with the axis of a rotary spindle chuck. The bar stock is incrementally advanced and gripped by the chuck, whereupon the spindle is rotated to facilitate processing of the exposed bar stock material.

There are basically two different ways to advance the bar stock through the spindle. One technique involves pulling the bar stock from the downstream processing end. In one such system, a turret, which carries processing tools, also carries a puller which releasably grips the exposed leading/downstream end of the bar stock and draws it in an advancing direction sufficiently that it can be gripped to perform a processing operation thereon. Alternatively, the bar stock is pushed from a trailing/upstream end thereof to effect incremental advancement thereof through the spindle.

In many processing operations, the barstock is not matched to have a length that is an even multiple of the processed work piece length. As a result, there will remain an unusable piece of bar stock which must be removed from the feeder assembly before another longer piece of bar stock can be substituted therefor, advanced, and processed. If the unusable piece is of a sufficient length, a puller, such as that on the aforementioned turret adjacent to the processing location, can be used to separate the bar piece from the feeder assembly. Generally, this method is not preferred in that the unusable bar piece may not be conveniently removable from the feeder assembly at the processing location. Removal in this manner may cause interference with succeeding operations using the same processing equipment or with operations performed by other adjacent processing equipment.

The more preferable method of removing the unusable bar stock is to withdraw the same from the upstream end of the feeder assembly. To do so requires that the unusable piece of bar stock be grippable from the upstream end of a feeder tube and within the feeder tube by a pulling mechanism. In one conventional construction, a retrieval assembly has a gripper element that surrounds the upstream end of the bar stock so that the gripper element projects radially beyond the outer surface of the bar stock. The gripper element travel in a downstream direction within the feeder tube may be limited by any restriction therein, such as at a bearing, a restriction in a collet chuck, or the like. The restriction may be axially located so that it prevents the gripper element from engaging a portion of a piece of bar stock of sufficient length in a manner so as to allow another usable workpiece to be processed. As a result, an otherwise usable piece of bar stock is rendered scrap by the system limitations. An accumulation of unusable bar pieces, aside from causing inconvenience, may represent a significant financial loss, not only from the standpoint of material waste, but also by reason of requiring more frequent bar stock replacement, which interferes with ongoing processing efficiency.

SUMMARY OF THE INVENTION

In one form, the invention is directed to a method of processing a piece of bar stock material having spaced ends and a predetermined diameter. The method includes the steps of: attaching an adaptor to one end of the piece of bar stock material; directing the piece of bar stock material into a feeder sleeve bounding an internal passageway; moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing; performing at least one processing step on the exposed part of the piece of bar stock material; engaging a retrieval assembly with the adaptor; extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway.

The adaptor may be attached to the piece of bar stock material before the piece of bar stock material is directed into the internal passageway. Alternatively, the adaptor may be attached to the piece of bar stock material with the piece of bar stock material extended at least partially into the internal passageway.

The adaptor may be attached to the one end of the piece of bar stock material in a number of different manners. As examples, the bar stock material may be attached by a spin welding process, by the use of a magnet, by a press-fit operation, through threaded engagement, etc.

The retrieval assembly may be engaged with the adaptor by a press-fitting operation.

In one form, the retrieval assembly has a first shoulder facing in a first direction, with the adaptor having a second shoulder facing oppositely to the first direction with the retrieval assembly engaged with the adaptor. The first and second shoulders abut each other so that the first shoulder acts against the second shoulder to cause the adaptor to follow movement of the retrieval assembly as the retrieval assembly repositions the piece of bar stock material.

At least one of the adaptor and retrieval assembly may be deformable to allow the first and second shoulders to be moved past each other and placed in facing relationship.

The method may further include the step of removing part of the piece of bar stock material during the performance of the at least one processing step so that a reduced size piece of the bar stock material resides at least partially in the internal passageway.

The method may include the step of removing the reduced size piece of the bar stock material from the internal passageway through the retrieval assembly.

The method may further include the step of separating the adaptor from the reduced size piece of bar stock material after the reduced size piece of bar stock material is removed from the internal passageway.

The adaptor that is separated from the reduced size piece of bar stock material may be attached to another piece of bar stock material.

The invention is also directed to a method of processing a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis. The method includes the steps of: engaging a retrieval assembly with one end of the piece of bar stock material so that at least a part of the retrieval assembly has another, second, effective diameter that is not greater than the first effective diameter so that the piece of bar stock material will follow movement of the retrieval assembly in at least one direction along the axis; directing the piece of bar stock material into a feeder sleeve bounding the internal passageway; moving the piece of bar stock material in the internal passageway so as to expose a part of the piece of bar stock material for processing; performing at least one processing step on the exposed part of the piece of bar stock material; and with the retrieval assembly engaged with the piece of bar stock material, moving the retrieval assembly along the axis within the internal passageway and thereby moving the piece of bar stock material within the internal passageway.

The step of moving the piece of bar stock material may involve moving the piece of bar stock material from a position wherein the piece of bar stock material resides at least partially within the hollow passageway to a position wherein the piece of bar stock material is fully removed from the hollow passageway.

The step of engaging a retrieval assembly may involve attaching an adaptor to the one end of the piece of bar stock material and engaging the retrieval assembly with the adaptor. Alternatively, the retrieval assembly may be engaged directly with the piece of bar stock material.

The invention is also directed to the combination of: a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis; an adaptor for attachment to one of the spaced ends of the piece of bar stock material with the adaptor in an operative position, wherein the adaptor does not project from the axis to beyond the first effective diameter of the peripheral surface; and a retrieval assembly engageable with the adaptor and which is repositionable to move the adaptor along the axis.

The retrieval assembly may be releasably attachable to the adaptor.

The combination may further include a feeder assembly including a sleeve with an internal passageway with a central axis and an effective diameter sufficiently large to receive the piece of bar stock material and least a part of the retrieval assembly.

The adaptor may be an element that is separate from and attached to the piece of bar stock material.

The invention is further directed to the combination of: a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis; a retrieval assembly engageable with the piece of bar stock material so that the at least part of the retrieval assembly does not project radially beyond the first predetermined diameter from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and a feeder assembly having a sleeve with an internal passageway with a central axis and an effective diameter sufficiently large to receive the piece of bar stock material and at least part of the retrieval assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a machine tool of the type with which the present invention can be practiced and with the present invention incorporated therein;

FIG. **2** is a side, partial cross-sectional, elevation view of the machine tool in FIG. **1**;

FIG. **3** is an enlarged, partial cross-sectional, partial schematic, view of the machine tool and feeder assembly of FIGS. **1** and **2** with a length of bar stock material having an adaptor, according to the present invention, attached to an end thereof and with the bar stock material being machined by a cutting tool;

FIG. **4** is a fragmentary, cross-sectional view of a conventional pusher assembly for advancing bar stock in a feeder assembly of the type shown in FIGS. **1–3**;

FIG. **5** is a fragmentary, partial cross-sectional view of a turret with a gripper to pull bar stock material in an advancing direction through a feeder assembly of the type shown in FIGS. **1–3**;

FIG. **6** is an enlarged, fragmentary, side elevation view of the adaptor on the piece of bar stock in FIG. **3**;

FIG. **7** is a side elevation view of a retrieval assembly, according to the present invention, for engaging the adaptor of FIG. **6**, which is repositionable through the retrieval assembly, to translate the adaptor and thus the bar stock material attached thereto;

FIG. **8** is an enlarged, side elevation view of another form of adaptor, according to the present invention;

FIG. **9** is an enlarged, end elevation view of a further modified form of adaptor, according to the present invention;

FIG. **10** is a side elevation view of the adaptor in FIG. **9**;

FIG. **11** is a fragmentary, side elevation view of a portion of a retrieval assembly, according to the present invention, for use with the adaptor in FIGS. **9** and **10**;

FIG. **12** is a front elevation view of the retrieval assembly in FIG. **11** with the retrieval assembly operatively engaged with the adapter in FIGS. **9** and **10**;

FIG. **13** is a side elevation view of a system for spin welding the adaptor of FIGS. **6–8** to a piece of bar stock material;

FIG. **14** is a fragmentary, partial cross-sectional, view showing another form of connection between an adaptor and a length of bar stock material, according to the present invention;

FIG. **15** is a view as in FIG. **14** of a further modified form of connection for an adaptor, according to the present invention;

FIG. **16** is a fragmentary, side elevation view showing a further modified form of retrieval assembly, according to the present invention, using a magnet to connect to a length of bar stock material; and

FIG. **17** is a generic representation of a retrieval assembly that is directly connected to a piece of bar stock material, according to the present invention without the need for an intermediate adaptor.

DETAILED DESCRIPTION OF THE DRAWINGS

In FIGS. **1–3**, one exemplary environment for the present invention is shown. More specifically, in FIGS. **1–3** a

machine tool is shown at **10** for processing elongate bar stock material **12**. Bar stock material may be solid or hollow in construction and may have any cross-sectional configuration. Typically, each length of bar stock material **12** has a round cross-sectional configuration, as shown in only an exemplary manner herein.

The machine tool **10** consists of a frame **13** which supports a rotary spindle assembly **14** and a tool turret **16**. The spindle assembly **14** has an associated feeder assembly **18** including a cylindrical, multi-part guide sleeve **20** having a central axis **22** that is coincident with the rotary axis **24** of a collet chuck **26** on the spindle assembly **14** and which releasably holds the bar stock material **12** in an operative position, as described hereinbelow. A brace element **28**, shown schematically, reinforces the feeder assembly **18** at a location spaced from the frame **13**.

In a typical processing operation, a length of the bar stock material **12** is directed into a hollow passageway **30** defined by the feeder assembly **18** at the upstream end **32** thereof. The length of bar stock material **12** is progressively moved downstream within the hollow passageway **30** in the direction of the arrow **34** to a position wherein a portion of the bar stock material **12** at the leading end **35** is exposed in a processing area **36** on the machine tool **10**. With a desired length of the bar stock material **12** exposed, the collet chuck **26** is operated to clamp against the bar stock material **12** and thereby fix the bar stock material **12** to the spindle assembly **14** for rotation therewith.

The spindle assembly **14** is rotatable by a motor **37** which drives a power transmission belt **38** which in turn drives a pulley **40** connected to the spindle assembly **14**. The spindle assembly **14** is guided smoothly in rotation by bearings **42**, **43** interposed between the sleeve **20** and a fixed housing **44**.

The tool turret **16** has individual cutting tools **46**, **48**, **50**, **52** thereon, as shown in schematic form, which can be selectively indexed to perform a desired processing operation on the portion of the bar stock material **12** projected through the collet chuck **26** and exposed at the processing area **36**. The tool turret **16** is mounted to the frame **13** in conventional fashion through a slide assembly **54** for multi-axis movement relative to the frame **13** and the bar stock material **12** held by the spindle assembly **14**.

At the completion of the processing of the exposed portion of the bar stock material **12**, a completed workpiece can be separated from the remainder of the bar stock material using a cutting tool **55**. Coordinated operation of the motor **37**, cutting tool **55**, and multi-axis drive **56** for the tool turret **16** is accomplished through a central controller **58**.

Once the processed portion of the barstock material **12** is separated, a portion of the bar stock material **12**, of reduced size, remains within the hollow passageway **30**. Typically, the starting bar stock material **12** has a length sufficient to allow several workpieces to be made therefrom. Upon completion of one workpiece, the reduced size portion of bar stock material is advanced from left to right in FIGS. **1–3** to allow the collet chuck **26** to grip the same with a sufficient length exposed to process another workpiece.

Axial translation of the bar stock material **12** through the passageway **30** is generally carried out conventionally in two different manners, as shown in FIGS. **4** and **5**. In FIG. **4**, a feeder assembly is shown at **60** which includes a gripper **62** to surroundingly engage the upstream end **64** of the bar stock material **12**. Through a rod **66**, the gripper **62**, and thus the bar stock material **12** held thereby, can be advanced along the line of the double-headed arrow **67** axially within the hollow passageway **30**.

As an alternative, as shown in FIG. **5**, a gripper **68** can be provided, as on the turret **16**, to engage the downstream end **34** of the bar stock material **12**. Through repositioning of the turret **16**, as by translatory movement in the line of the double-headed arrow **69**, the gripper **68** can be moved to reposition the bar stock material **12** within the hollow passageway **30** and to fully extract the bar stock material **12** from the hollow passageway **30**.

One difficulty with using the turret **16** to remove the bar stock material **12** is that this removal takes place in the processing area **36**. This may interfere with the basic operation of the machine tool **10**. Additionally, the remaining portion of the bar stock material **12** must have a length sufficient to allow the gripper **68** to effect engagement therewith. This could lead to significant waste of the bar stock, a problem previously described.

In the event that the system of FIG. **4** is utilized to push the bar stock material progressively towards the processing area **36**, the gripper **62**, which is dimensioned to move within the passageway **30**, may be limited in its downstream translation, by a restriction within the passageway, such as that at a collet bearing **69** (FIG. **3**), or a restriction **70** in the collet chuck **26**, which reduces the effective diameter of the passageway **30** thereat to less than the effective diameter of the outer surface of the gripper **62**. The gripper **62** can engage and advance the bar stock material downstream only so long as the bar stock material has a length L**1** in FIG. **3** extending from the upstream end of the collet bearing **69** to the downstream end **71** of the passageway **30** plus a) the additional length L**2** required for the gripper **62** to engage the bar stock material and b) the projecting length L**3** of the bar stock material required for processing. Accordingly, if the unused portion of the bar stock material **12** is to be withdrawn from or advanced in the hollow passageway **30** using the gripper **62** which cannot pass downstream past the collet bearing **70**, the bar stock material **12** must have a length at least equal to the combined length L**1**+L**2**+L**3**. A combined length less than L**1**+L**2** +L**3** may be greater than the required length for a completed workpiece. However, it could not be processed using the conventional gripper **62**. In this situation, the bar stock material **12** is conventionally removed and potentially disposed of, whereas it might otherwise be usable to make one or more additional workpieces. A substantial amount of the bar stock may as a result be wasted.

To alleviate this problem, the invention contemplates a bar stock retrieval system constructed so that the bar stock material **12** can be selectively advanced and withdrawn in an axial direction within the hollow passageway **30** past a restriction in the passageway that will allow passage of the bar stock **12** but not the larger diameter gripper **62**. One manner of facilitating this, according to the present invention, is to attach an adaptor **74** at the upstream end **64** of the bar stock material **12**, as shown in FIGS. **3** and **6**. The invention contemplates that the adaptor **74** can have a number of different configurations and could be attached to the bar stock material **12** in any of a number of different manners. It is preferred that the adaptor **74** not project from the axis **22** radially outwardly beyond the effective diameter D (FIG. **3**) of the bar stock material **12**. The "effective" diameter, as used throughout the description herein, is the smallest diameter of a cylinder coaxial with the bar stock material **12** that will contain the outer peripheral surface **76** of the bar stock material **12**.

In the form shown in FIGS. **3** and **6**, the adaptor **74** has a stem **78** with an enlarged head **80** on the end of the stem **78**. The enlarged head **80** has a rounded shape. The head **80**

is designed to cooperate with a retrieval assembly, as shown at **82** in FIG. **7**. The retrieval assembly consists **82** of an elongate rod **84** with a fitting **86** at one end thereof. A drive **88** advances the rod **84** along the line of the double-headed arrow **90**, i.e., parallel to the passageway axis **22**. The fitting **86** consists of an enlargement **92** with a slot **94** therein that bifurcates the enlargement **92**. Spaced enlargement parts **96,98** cooperatively define a receptacle **100** which is complementary to the peripheral outer surface **102** of the enlarged head **80** of the adaptor **74**.

By advancing the fitting **86** against the enlarged head **80**, the parts **96,98** are progressively cammed away from each other to the dotted line position, which allows the enlarged head **80** to seat in the receptacle **100**. With the enlarged head **80** fully seated, an annular shoulder **104**, bounding the receptacle **100**, abuts to an oppositely facing annular shoulder **106** on the enlarged head **80**. With this arrangement, right-to-left movement of the fitting **86** in FIG. **7** causes the shoulder **104** to bear on the shoulder **106** to urge the adaptor **74**, and the bar stock material **12** attached thereto, in the same direction. This cooperative arrangement permits movement of the bar stock material **12** by the retrieval assembly **82** in opposite axial directions within the passageway **30**.

Many variations of the retrieval assembly **82** and adaptor **74** are contemplated. As just one example, the rod **84** can be made with telescoping segments so as to be reconfigurable by varying the relationship of the telescoping sections to alter the effective length thereof.

As far as the adaptor **74** is concerned, it can take a virtually limitless number of shapes different from that shown in FIG. **6**. As just an example, an adaptor, as shown at **110** in FIG. **8**, can be utilized with a stem **112** and an enlarged head **114** in the form of a truncated cone. A surface **116** thereon serves as a cam surface to progressively deform a complementary fitting (not shown) that operates generally as the fitting **86**, as shown in FIG. **7**.

As an alternative to using a deformable fitting, an adaptor, as shown at **120** in FIGS. **9** and **10**, can be used, which adaptor **120** cooperates with a retrieval assembly as shown at **122** in FIGS. **11** and **12**. The adaptor **120** has a stem **124** and a squared, enlarged head **125**.

The retrieval assembly **122** consists of a rod **126** with a fitting **128** on an end thereof. The fitting **128** is in the form of a block with an internal, cylindrical chamber **129** having a diameter D at least equal to the diagonal dimension X of a leading face **130** of the enlarged head **125**. An entry opening **132**, having a shape and dimension corresponding to the front face **130**, is provided through the front surface **134** of the fitting **128** and communicates from there to the chamber **129**.

With this arrangement, the rod **126** can be advanced axially so that the adaptor moves within the passage **30**. The retrieval assembly **122** and adaptor **120** can be relatively rotated to align the enlarged head **125** so that it can pass axially through the entry opening **132**. By advancing the rod **126**, the enlarged head **125** can be passed fully through the entry opening **132** and into the chamber **129**, whereupon relative rotation between the retrieval assembly **122** and adaptor **124** causes the enlarged head **125** to assume the dotted line position in FIG. **12**, wherein axial separation of the adaptor **120** and retrieval assembly **122** is precluded by abutment of the shoulder **136** on the enlarged head **125** and a confronting shoulder **138** bounding the chamber **129** on the fitting **128**.

With this arrangement, the retrieval assembly **122** can be advanced towards the adaptor **120** to cause the head **125** to pass into the chamber **129**, whereupon relative rotation between the retrieval assembly **122** and adaptor **120** places the enlarged head **125** in the FIG. **12** position. Withdrawal of the retrieval assembly **122** from the hollow passageway **30** thus draws the adaptor **120** and associated bar stock material **12**. The retrieval assembly **122** so engaged can be used to move the engaged bar stock material **12** in opposite axial directions within the passageway **30**.

Preferably, the radial dimension of the fittings **86**, **128** is such that they do not exceed the effective diameter D of the opening through the collet bearing **69**, and any like restriction **70** in the collet chuck **26**, which is less than the diameter D1 of the hollow passageway **30**, so that the fittings **86**, **128** can be passed downstream through the collet bearing opening and collet chuck **26**. Preferably, the radial dimensions of the fittings **86**, **128** reside within the effective diameter of the piece of bar stock material **12** so as not to represent any impediment to translation of the bar stock material **12**. Potentially then, the only restriction on downstream movement of the remaining piece of bar stock **12** is that it must be sufficiently long to be holdable by the collet chuck **26**.

The adaptors **74**, **110**, **120** can be attached to the bar stock material **12** in a number of different manners. One manner of joining the exemplary adaptor **74** is described with respect to FIG. **13**. In FIG. **13**, the adaptor **74** is mounted on a first rotary spindle **142**. The bar stock material **12** is mounted to a second rotary spindle **144**. The spindles **142**, **144** are relatively repositionable along the line of the double-headed arrow **145** so that the adaptor **74** can be abutted to the upstream end **64** of the bar stock material **12**. With the adaptor **74** against the bar stock material **12**, the spindles **142**, **144** are relatively rotatable in opposite directions, as indicated by the arrows **146**, **148**, with pressure applied to cause a fusion of the adaptor **74** and bar stock material **12** through a spin welding process.

Alternatively, as shown in FIG. **14**, a head **149** connects to a stem **150**, which has a tapered end **152** which can be press fit into a bore **154** in the bar stock material **12**. The adaptor **150** can be attached by a press-fit step which may be carried out by a hammer blow, or continuous pressure application.

As a further alternative, an adaptor **160** with a head **162** has a threaded stem **162** which can be driven or threaded into a bore **164** in the bar stock material **12**. The bore **164** can be threaded or unthreaded.

Many other variations of adaptors are contemplated by the invention. As just examples, the adaptors might be welded other than by spin welding, or held in place by an adhesive.

As a further alternative for practicing the invention, as shown in FIG. **16**, a retrieval assembly **166** may be utilized with a magnet **168** incorporated into a rod **170**. The rod **170** may shield the magnet **168** from the other components of the machine tool **10**. With this arrangement, the rod **170** can be advanced until the magnet **168** attracts the end **64** of the bar stock material **12**.

Regardless of the configuration of the adaptor and retrieval assembly, the processing of the piece of bar stock material **12** can be carried out in any of a number of different manners. For example, the adaptor can be attached to the bar stock material **12** either before or after the bar stock material **12** is introduced to the hollow passageway **30**. The adaptor can be used to advance the bar stock material **12** as different machining operations are performed and progressively reduce the length of the bar stock material **12**. Once the usable length of the bar stock material **12** is exhausted, the adaptor can be used to engage the retrieval assembly, which

withdraws the unusable portion of the bar stock material fully out of the hollow passageway **30** through the upstream end **32** thereof. The retrieval assembly could also be used as a pusher to advance the bar stock fully through the spindle at the downstream end of the passageway **30**.

The adaptors can be disposed of with the remaining length of bar stock material **12** or can be separated therefrom for re-use in the same manner as described above. The adaptors can be made from any material, including metal, plastic, etc. to carry out the function described above. It is only necessary that the adaptor have enough integrity and be attached to the bar stock material **12** with sufficient strength to allow the bar stock material **12** to be translated by manipulation of the adaptor. The manipulating portion of the retrieval assemblies can be directed into the hollow passageway **30** so that potentially the full usable length of the bar stock material **12** can be processed.

The invention also contemplates that the retrieval assembly could be engaged with the bar stock material without the use of any adaptor. As shown in FIG. **17**, it is desirable with all embodiments that the effective diameter D**2** of a moving part **180** of a retrieval assembly **182** within the passageway **30** be less than or equal to the effective diameter D**3** of a piece of bar stock material **12**. The moving part **180** of the retrieval assembly **182** may be advanced in the downstream direction, as indicated by the arrow **184** fully through the passageway **30** and potentially fully through the spindle assembly **14**. To function in this manner only as a pusher, the moving part **180** of the retrieval assembly **182** need not be connected to the bar stock material.

To function to retrieval/move the bar stock material **12** in an upstream direction, the moving part **80** is connected to the piece of bar stock **12**. In FIG. **17**, a generic connection is shown at **186**. The connection can be effected by an adhesive, soldering, a weld, magnets, etc. Virtually any connection that causes the bar stock material **12** to follow upstream translation of the moving part **180** can be used. Preferably the effective diameter at the connection does not project beyond the diameter D**3** of the outer surface of the bar stock material **12**.

The foregoing disclosure of specific embodiments is intended to be illustrative of the broad concepts comprehended by the invention.

I claim:

1. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway so that no part of the retrieval assembly projects radially beyond the predetermined diameter from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway.

2. The method of processing a piece of bar stock material according to claim **1** wherein the adaptor is attached to the piece of bar stock material before the piece of bar stock material is directed into the internal passageway.

3. The method of processing a piece of bar stock material according to claim **1** wherein the adaptor is attached to the one end of the piece of bar stock material by a press-fitting operation.

4. The method of processing a piece of bar stock material according to claim **1** wherein the retrieval assembly is engaged with the adaptor by a press-fitting operation.

5. The method of processing a piece of bar stock material according to claim **1** further comprising the step of removing part of the piece of bar stock material during the performance of the at least one processing step so that a reduced size piece of the bar stock material resides in the passageway.

6. The method of processing a piece of bar stock material according to claim **5** further comprising the step of removing the reduced size piece of the bar stock material from the passageway through the retrieval assembly.

7. The method of processing a piece of bar stock material according to claim **6** further comprising the step of separating the adaptor from the reduced size piece of bar stock material after the reduced size piece of bar stock material is removed from the passageway.

8. The method of processing a piece of bar stock material according to claim **7** further comprising the step of attaching the adaptor separated from the reduced size piece of bar stock material to another piece of bar stock material.

9. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway,

wherein the adaptor is attached to the piece of bar stock material with the piece of bar stock material extending at least partially into the internal passageway.

10. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway,

wherein the adaptor is attached to the one end of the piece of bar stock material by a spin welding process.

11. The method of processing a piece of bar stock material according to claim **10** wherein the step of extending at least a part of the retrieval assembly into the internal passageway comprises extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter.

12. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway,

wherein the adaptor is attached to the one end of the piece of bar stock material through the use of a magnet.

13. The method of processing a piece of bar stock material according to claim **12** wherein the step of extending at least a part of the retrieval assembly into the internal passageway comprises extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter.

14. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway,

wherein the adaptor is threadably attached to the one end of the piece of bar stock material.

15. The method of processing a piece of bar stock material according to claim **14** wherein the step of extending at least a part of the retrieval assembly into the internal passageway comprises extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter.

16. A method of processing a piece of bar stock material having spaced ends and a predetermined diameter, said method comprising the steps of:

attaching an adaptor to one end of the piece of bar stock material;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway from an upstream end of the internal passageway towards a downstream end of the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material;

engaging a retrieval assembly with the adaptor;

extending at least a part of the retrieval assembly into the internal passageway from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

with the retrieval assembly engaged with the adaptor, repositioning the retrieval assembly to thereby reposition the piece of bar stock material within the internal passageway,

wherein the retrieval assembly has a first shoulder facing in a first direction and the adaptor has a second shoulder facing oppositely to the first direction, with the retrieval assembly engaged with the adaptor, the first and second shoulders abut each other and the first shoulder acts against the second shoulder to cause the adaptor to follow movement of the retrieval assembly as the retrieval assembly repositions the piece of bar stock material.

17. The method of processing a piece of bar stock material according to claim **16** wherein at least one of the adaptor and retrieval assembly is deformable to allow the first and second shoulders to be moved past each other and placed in facing relationship.

18. The method of processing a piece of bar stock material according to claim **16** wherein the step of extending at least

a part of the retrieval assembly into the internal passageway comprises extending at least a part of the retrieval assembly into the internal passageway so that the at least part of the retrieval assembly does not project radially beyond the predetermined diameter.

19. A method of processing a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis, said method comprising the steps of:

engaging a retrieval assembly with one end of the piece of bar stock material so that no part of the retrieval assembly at a location at which the retrieval assembly engages the bar stock material has an outer, effective diameter that is greater than the first effective diameter and so that the piece of bar stock material will follow movement of the retrieval assembly in at least one direction along the axis;

directing the piece of bar stock material into a feeder sleeve bounding an internal passageway;

moving the piece of bar stock material in the internal passageway so as to expose a part of the piece of bar stock material for processing;

performing at least one processing step on the exposed part of the piece of bar stock material; and

with the retrieval assembly engaged with the piece of bar stock material, moving the retrieval assembly along the axis within the internal passageway and thereby moving the piece of bar stock material within the internal passageway.

20. A method of processing a piece of bar stock material according to claim **19** wherein the step of moving the piece of bar stock material comprises moving the piece of bar stock material from a position wherein the piece of bar stock material resides at least partially within the hollow passageway to a position wherein the piece of bar stock material is fully removed from the hollow passageway.

21. The method of processing a piece of bar stock material according to claim **19** wherein the step of engaging a retrieval assembly comprises attaching an adaptor to the one end of the piece of bar stock material and engaging the retrieval assembly with the adaptor.

22. The method of processing a piece of bar stock material according to claim **19** wherein the step of engaging a retrieval assembly comprises engaging the retrieval assembly directly with the one end of the piece of bar stock material.

23. A bar stock retrieval system comprising:

a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis;

an adaptor at one of the spaced ends of the piece of bar stock material with the adaptor in an operative position, wherein the adaptor does not project from the axis to beyond the first effective diameter of the peripheral surface; and

a retrieval assembly engageable with the adaptor and which is repositionable to move the adaptor along the axis.

24. The bar stock retrieval system according to claim **23** wherein the retrieval assembly is releasably attachable to the adaptor.

25. The bar stock retrieval system according to claim **23** further in combination with a feeder assembly comprising a sleeve with an internal passageway with a central axis and an effective diameter sufficiently large to receive the piece of bar stock material and at least a part of the retrieval assembly.

26. The bar stock retrieval system according to claim **23** wherein the adaptor is an element that is separate from and attached to the piece of bar stock material.

27. A bar stock retrieval system comprising:

a piece of bar stock material having spaced ends between which an axis extends and a peripheral surface with a first effective diameter around the axis;

a retrieval assembly engageable with the piece of bar stock material so that the at least part of the retrieval assembly at a location at which the retrieval assembly engages the bar stock material does not project radially beyond the first predetermined diameter from a downstream end of the at least part of the retrieval assembly to a predetermined distance in an upstream direction; and

a feeder assembly comprising a sleeve with an internal passageway with a central axis and an effective diameter sufficiently large to receive the piece of bar stock material and the at least a part of the retrieval assembly.

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